PROGRAMMER'S AID #1

INSTALLATION AND OPERATING MANUAL

FOR USE ONLY
WITH INTEGER
BASIC PROGRAMS

Apple Utility Programs

FOR USE WITH INTEGER BASIC

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INTRODUCTION

FEATURES OF PROGRAMMER'S AID #1

Programmer's Aid #1 combines several APPLE II programs that Integer BASIC programmers need quite frequently. To avoid having to load them from a cassette tape or diskette each time they are used, these programs have been combined in a special read-only memory (ROM) integrated circuit (IC). When this circuit is plugged into one of the empty sockets left on the APPLE's printed-circuit board for this purpose, these programs become a built-in part of the computer the same way Integer BASIC and the Monitor routines are built in. Programmer's Aid #1 allows you to do the following, on your APPLE II:

Chapter 1. Renumber an entire Integer BASIC program, or a portion of the program.

Chapter 2. Load an Integer BASIC program from tape without erasing the Integer BASIC program that was already in memory, in order to combine the two programs.

Chapter 3. Verify that an Integer BASIC program has been saved correctly on tape, before the program is deleted from APPLE's memory.

Chapter 4. Verify that a machine-language program or data area has been saved correctly on tape from the Monitor.

Chapter 5. Relocate 65Ø2 machine-language programs.

Chapter 6. Test the memory of the APPLE.

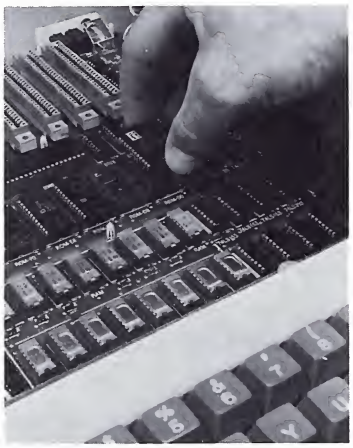
Chapter 7. Generate musical notes of variable duration over four chromatic octaves, in five (slightly) different timbres, from Integer BASIC.

Chapter 8. Do convenient High-Resolution graphics from Integer BASIC.

Note: if your APPLE has the firmware APPLESOFT card installed, its switch must be down (in the Integer BASIC position) for Programmer's Aid #1 to operate.

HOW TO INSTALL THE PROGRAMMER'S AID ROM

The Programmer's Aid ROM is an IC that has to be plugged into a socket on the inside of the APPLE II computer.



1. Turn off the power switch on the back of the APPLE II. This is important to prevent damage to the computer.

2. Remove the cover from the APPLE II. This is done by pulling up on the cover at the rear edge until the two corner fasteners pop apart. Do not continue to lift the rear edge, but slide cover backward until it comes free.

3. Inside the APPLE, toward the right center of the main printed-circuit board, locate the large empty socket in Row F, marked "ROM-DØ".

4. Make sure that the Programmer's Aid ROM IC is oriented correctly. The small semicircular notch should be toward the keyboard. The Programmer's Aid ROM IC must match the orientation of the other ROM ICs that are already installed in that row.

5. Align all the pins on the Programmer's Aid ROM IC with the holes in socket DØ, and gently press the IC into place. If a pin bends, remove the IC from its socket using an "IC puller" (or, less optimally, by prying up gently with a screwdriver). Do not attempt to pull the socket off the board. Straighten any bent pins with a needlenose pliers, and press the IC into its socket again, even more carefully.

6. Replace the cover of the APPLE, remembering to start by sliding the front edge of the cover into position. Press down on the two rear corners until they pop into place.

7. Programmer's Aid #1 is installed; the APPLE II may now be turned on.

CHAPTER 1
RENUMBER

RENUMBERING AN ENTIRE BASIC PROGRAM

After loading your program into the APPLE, type the

```
CLR
```

command. This clears the BASIC variable table, so that the Renumber feature's parameters will be the first variables in the table. The Renumber feature looks for its parameters by location in the variable table. For the parameters to appear in the table in their correct locations, they must be specified in the correct order and they must have names of the correct length.

Now, choose the number you wish assigned to the first line in your renumbered program. Suppose you want your renumbered program to start at line number 1ØØØ. Type

```
START = 1ØØØ
```

Any valid variable name will do, but it must have the correct number of characters. Next choose the amount by which you want succeeding line numbers to increase. For example, to renumber in increments of 1Ø, type

```
STEP = 1Ø
```

Finally, type the this command:

```
CALL -1Ø531
```

As each line of the program is renumbered, its old line number is displayed with an "arrow" pointing to the new line number. A possible example might appear like this on the APPLE's screen:

```
7->1ØØØ
213->1Ø1Ø
527->1Ø2Ø
698->1Ø3Ø
13ØØØ->1Ø4Ø
13233->1Ø5Ø
```

RENUMBERING PORTIONS OF A PROGRAM

You do not have to renumber your entire program. You can renumber just the lines numbered from, say, 3ØØ to 5ØØ by assigning values to four variables. Again, you must first type the command

```
CLR
```

to clear the BASIC variable table.

The first two variables for partial renumbering are the same as those for renumbering the whole program. They specify that the program portion, after renumbering, will begin with line number 2ØØ, say, and that each line's number thereafter will be 2Ø greater than the previous line's:

```
START = 2ØØ
STEP = 2Ø
```

The next two variables specify the program portion's range of line numbers before renumbering:

```
FROM = 3ØØ
TO = 5ØØ
```

The final command is also different. For renumbering a portion of a program, use the command:

```
CALL -1Ø521
```

If the program was previously numbered

```
 1ØØ
 12Ø
 3ØØ
 31Ø
 4Ø2
 5ØØ
2ØØØ
2Ø22
```

then after the renumbering specified above, the APPLE will show this list of changes:

```
3ØØ->2ØØ
31Ø->22Ø
4Ø2->24Ø
5ØØ->26Ø
```

and the new program line numbers will be

```
 1ØØ
 12Ø
 2ØØ
 22Ø
 24Ø
 26Ø
2ØØØ
2Ø22
```

You cannot renumber in such a way that the renumbered lines would replace, be inserted between or be intermixed with un-renumbered lines. Thus, you cannot change the order of the program lines. If you try, the message

*** RANGE ERR

is displayed after the list of proposed line changes, and the line numbers themselves are left unchanged. If you type the commands in the wrong order, nothing happens, usually.

COMMENTS:

1. If you do not CLR before renumbering, unexpected line numbers may result. It may or may not be possible to renumber the program again and save your work.

2. If you omit the START or STEP values, the computer will choose them unpredictably. This may result in loss of the program.

3. If an arithmetic expression or variable is used in a GOTO or GOSUB, that GOTO or GOSUB will generally not be renumbered correctly. For example, GOTO TEST or GOSUB 10+20 will not be renumbered correctly.

4. Nonsense values for STEP, such as 0 or a negative number, can render your program unusable. A negative START value can renumber your program with line numbers above 32767, for what it's worth. Such line numbers are difficult to deal with. For example, an attempt to LIST one of them will result in a >32767 error. Line numbers greater than 32767 can be corrected by renumbering the entire program to lower line numbers.

5. The display of line number changes can appear correct even though the line numbers themselves have not been changed correctly. After the *** RANGE ERR message, for instance, the line numbers are left with their original numbering. LIST your program and check it before using it.

6. The Renumber feature applies only to Integer BASIC programs.

7. Occasionally, what seems to be a "reasonable" renumbering does not work. Try the renumbering again, with a different START and STEP value.

CHAPTER 2
APPEND

APPENDING ONE BASIC PROGRAM TO ANOTHER

If you have one program or program portion stored in your APPLE's memory, and another saved on tape, it is possible to combine them into one program. This feature is especially useful when a subroutine has been developed for one program, and you wish to use it in another program without retyping the subroutine.

For the Append feature to function correctly, all the line numbers of the program in memory must be greater than all the line numbers of the program to be appended from tape. In this discussion, we will call the program saved on tape "Program1," and the program in APPLE's memory "Program2."

If Program2 is not in APPLE's memory already, use the usual command

```
LOAD
```

to put Program2 (with high line numbers) into the APPLE. Using the Renumber feature, if necessary, make sure that all the line numbers in Program2 are greater than the highest line number in Program1.

Now place the tape for Program1 in the tape recorder. Use the usual loading procedure, except that instead of the LOAD command use this command:

```
CALL -11Ø76
```

This will give the normal beeps, and when the second beep has sounded, the two programs will both be in memory. If this step causes the message

```
*** MEM FULL ERR
```

to appear, neither Program2 nor Program1 will be accessible. In this case, use the command

```
CALL -11Ø59
```

to recover Program2, the program which was already in APPLE's memory.

COMMENTS:

1. The Append feature operates only with APPLE II Integer BASIC programs.

2. If the line numbers of the two progams are not as described, expect unpredictable results.

CHAPTER 3
TAPE VERIFY (BASIC)

VERIFYING A BASIC PROGRAM SAVED ON TAPE

Normally, it is impossible (unless you have two APPLEs) to know whether or not you have successfully saved your current program on tape, in time to do something about a defective recording. The reason is this: when you SAVE a program on tape, the only way to discover whether it has been recorded correctly is to LOAD it back in to the APPLE. But, when you LOAD a program, the first thing the APPLE does is erase whatever current program is stored. So, if the tape is bad, you only find out after your current program has been lost.

The Tape Verify feature solves this problem. Save your current program in the usual way:

```
SAVE
```

Rewind the tape, and (without modifying your current program in any way) type the command

```
CALL -1Ø955
```

Do not press the RETURN key until after you start the tape playing. If the tape reads in normally (with the usual two beeps), then it is correct. If there is any error on the tape, you will get a beep and the ERR message. If this happens, you will probably want to try re-recording the tape, although you don't know for sure whether the Tape Verify error means that the tape wasn't recorded right or if it just didn't play back properly. In any case, if it does verify, you know that it is good.

COMMENTS:

1. This works only with Integer BASIC programs.

2. Any change in the program, however slight, between the time the program is SAVEd on tape and the time the tape is verified, will cause the verification to fail.

CHAPTER 4
TAPE VERIFY (Machine Code or Data)

```
1Ø    Verifying a portion of memory saved on tape
1Ø    Comments
```

VERIFYING A PORTION OF MEMORY SAVED ON TAPE

Users of machine-language routines will find that this version of the Tape Verify feature meets their needs. Save the desired portion of memory, from address1 to address2, in the usual way:

address1 . address2 W return

Note: the example instructions in this chapter often include spaces for easier reading; do not type these spaces.

Rewind the tape, and type (after the asterisk prompt)

D52EG return

This initializes the Tape Verify feature by preparing locations $3F8 through $3FA for the ctrl Y vector. Now type (do not type the spaces)

address1 . address2 ctrl Y return

and re-play the tape. The first error encountered stops the program and is reported with a beep and the word ERR. If it is not a checksum error, then the Tape Verify feature will print out the location where the tape and memory disagreed and the data that it expected on the tape.

Note: type "ctrl Y" by typing Y while holding down the CTRL key; ctrl Y is not displayed on the TV screen. Type "return" by pressing the RETURN key.

COMMENTS:

Any change in the specified memory area, however slight, between the time the program is saved on tape and the time the tape is verified, will cause the verification to fail.

CHAPTER 5
RELOCATE

PART A: THEORY OF OPERATION

RELOCATING MACHINE-LANGUAGE CODE

Quite frequently, programmers encounter situations that call for relocating machine-language (not BASIC) programs on the 65Ø2-based APPLE II computer. Relocation implies creating a new version of the program, a version that runs properly in an area of memory different from that in which the original program ran.

If they rely on the relative branch instruction, certain small 65Ø2 programs can simply be moved without alteration, using the existing Monitor Move commands. Other programs will require only minor hand-modification after Monitor Moving. These modifications are simplified on the APPLE II by the built-in disassembler, which pinpoints absolute memory-reference instructions such as JMP's and JSR's.

However, sometimes it is necessary to relocate lengthy programs containing multiple data segments interspersed with code. Using this Machine-Code Relocation feature can save you hours of work on such a move, with improved reliability and accuracy.

The following situations call for program relocation:

1. Two different programs, which were originally written to run in identical memory locations, must now reside and run in memory concurrently.

2. A program currently runs from ROM. In order to modify its operation experimentally, a version must be generated which runs from a different set of addresses in RAM.

3. A program currently running in RAM must be converted to run from EPROM or ROM addresses.

4. A program currently running on a 16K machine must be relocated in order to run on a 4K machine. Furthermore, the relocation may have to be performed on the smaller machine.

5. Because of memory-mapping differences, a program that ran on an APPLE I (or other 65Ø2-based computer) falls into unusable address space on an APPLE II.

6. Because different operating systems assign variables differently, either page-zero or non-page-zero variable allocation for a specific program may have to modified when moving the program from one make of computer to another.

7. A program, which exists as several chunks strewn about memory, must be combined in a single, contiguous block.

8. A program has outgrown the available memory space and must be relocated to a larger, "free" memory space.

9. A program insertion or deletion requires a portion of the program to move a few bytes up or down.

1Ø. On a whim, the user wishes to move a program.

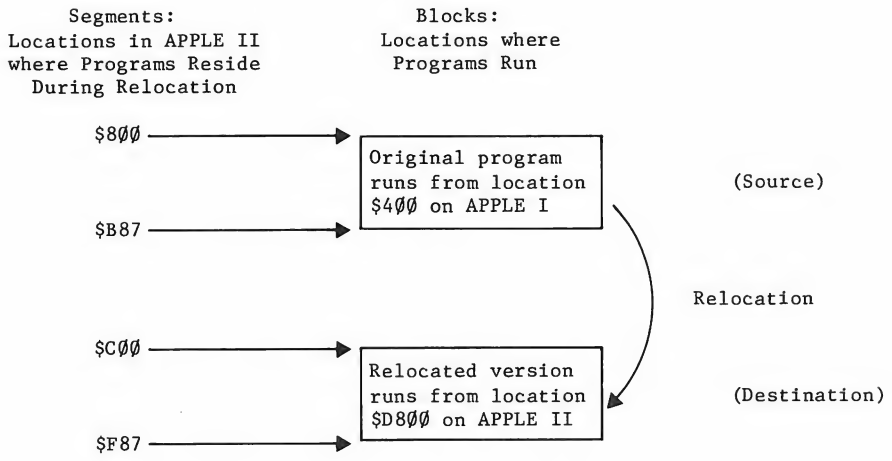
PROGRAM MODEL

Here is one simple way to visualize program relocation: starting with a program which resides and runs in a "Source Block" of memory, relocation creates a modified version of that program which resides and runs properly in a "Destination Block" of memory.

However, this model does not sufficiently describe situations where the "Source Block" and the "Destination Block" are the same locations in memory. For example, a program written to begin at location $4ØØ on an APPLE I (the $ indicates a hexadecimal number) falls in the APPLE II screen-memory range. It must be loaded to some other area of memory in the APPLE II. But the program will not run properly in its new memory locations, because various absolute memory references, etc., are now wrong. This program can then be "relocated" right back into the same new memory locations, a process which modifies it to run properly in its new location.

A more versatile program model is as follows. A program or section of a program written to run in a memory range termed the "Source Block" actually resides currently in a range termed the "Source Segments". Thus a program written to run from location $4ØØ may currently reside beginning at location $8ØØ. After relocation, the new version of the program must be written to run correctly in a range termed the "Destination Block" although it will actually reside currently in a range termed the "Destination Segments". Thus a program may be relocated such that it will run correctly from location $D8ØØ (a ROM address) yet reside beginning at location $CØØ prior to being saved on tape or used to burn EPROMs (obviously, the relocated program cannot immediately reside at locations reserved for ROM). In some cases, the Source and Destination Segments may overlap.

BLOCKS AND SEGMENTS EXAMPLE



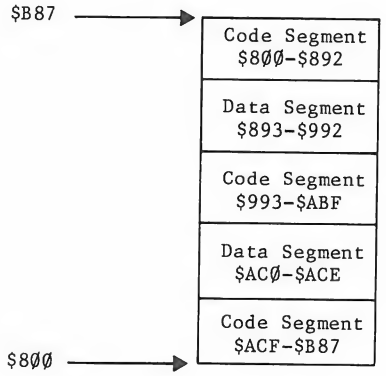
SOURCE BLOCK: $4ØØ-$787 DESTINATION BLOCK: $D8ØØ-$DB87

SOURCE SEGMENTS: $8ØØ-$B87 DESTINATION SEGMENTS: $CØØ-$F87

DATA SEGMENTS

The problem with relocating a large program all at once is that blocks of data (tables, text, etc.) may be interspersed throughout the code. During relocation, this data may be treated as if it were code, causing the data to be changed or causing code to be altered incorrectly because of boundary uncertainties introduced when the data takes on the multi-byte attribute of code. This problem is circumvented by dividing the program into code segments and data segments, and then treating the two types of segment differently.

CODE AND DATA SEGMENTS EXAMPLE



The Source Code Segments are relocated (using the 65Ø2 Code-Relocation feature), while the Source Data Segments are moved (using the Monitor Move command).

HOW TO USE THE CODE-RELOCATION FEATURE

1. To initialize the 65Ø2 Code-Relocation feature, press the RESET key to invoke the Monitor, and then type

```
D4D5G return
```

The Monitor user function ctrl Y will now call the Code-Relocation feature as a subroutine at location $3F8.

Note: To type "ctrl Y", type Y while holding down the CTRL key. To type "return", press the RETURN key. In the remainder of this discussion, all instructions are typed to the right of the Monitor prompt character (*). The example instructions in this chapter often include spaces for easier reading; do not type these spaces.

2. Load the source program into the "Source Segments" area of memory (if it is not already there). Note that this need not be where the program normally runs.

3. Specify the Destination and Source Block parameters. Remember that a Block refers to locations from which the program will run, not the locations at which the Source and Destination Segments actually reside during the relocation. If only a portion of a program is to be relocated, then that portion alone is specified as the Block.

```
DEST BLOCK BEG  <  SOURCE BLOCK BEG . SOURCE BLOCK END  ctrl Y  *  return
```

Notes: the syntax of this command closely resembles that of the Monitor Move command. Type "ctrl Y" by pressing the Y key while holding down the CTRL key. Then type an asterisk (*); and finally, type "return" by pressing the RETURN key. Do not type any spaces within the command.

4. Move all Data Segments and relocate all Code Segments in sequential (increasing address) order. It is wise to prepare a list of segments, specifying beginning and ending addresses, and whether each segment is code or data.

If First Segment is Code:

DEST SEGMENT BEG < SOURCE SEGMENT BEG . SOURCE SEGMENT END ctrl Y return

If First Segment is Data:

DEST SEGMENT BEG < SOURCE SEGMENT BEG . SOURCE SEGMENT END M return

After the first segment has been either relocated (if Code) or Moved (if data), subsequent segments can be relocated or Moved using a shortened form of the command.

Subsequent Code Segments:

. SOURCE SEGMENT END ctrl Y return (Relocation)

Subsequent Data Segments:

. SOURCE SEGMENT END M return (Move)

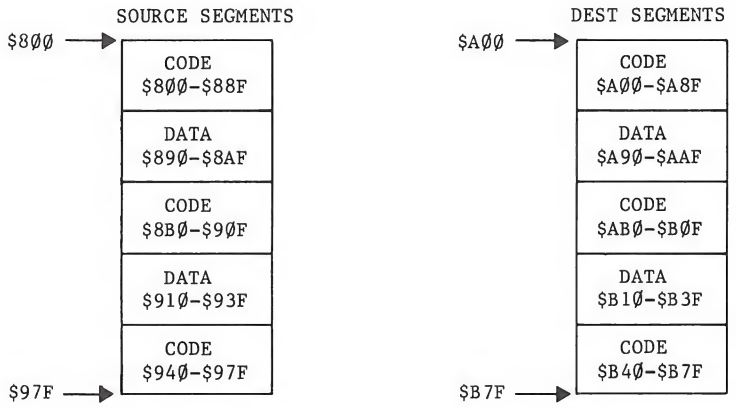
Note: the shortened form of the command can only be used if each "subsequent" segment is contiguous to the segment previously relocated or Moved. If a "subsequent" segment is in a part of memory that does not begin exactly where the previous segment ended, it must be Moved or relocated using the full "First Segment" format.

If the relocation is performed "in place" (SOURCE and DEST SEGMENTs reside in identical locations) then the SOURCE SEGMENT BEG parameter may be omitted from the First Segment relocate or Move command.

PART B: CODE-RELOCATION EXAMPLES

EXAMPLE 1. Straightforward Relocation

Program A resides and runs in locations $8ØØ-$97F. The relocated version will reside and run in locations $AØØ-$B7F.



SOURCE BLOCK: $8ØØ-$97F
SOURCE SEGMENTS: $8ØØ-$97F

DEST BLOCK: $AØØ-$B7F
DEST SEGMENTS: $AØØ-$B7F

(a) Initialize Code-Relocation feature:

reset D4D5G return

(b) Specify Destination and Source Block parameters (locations from which the program will run):

AØØ < 8ØØ . 97F ctrl Y * return

(c) Relocate first segment (code):

AØØ < 8ØØ . 88F ctrl Y return

(d) Move subsequent Data Segments and relocate subsequent Code Segments, in ascending address sequence:

```
. 8AF  M  return                    (data)
. 90F  ctrl Y  return               (code)
. 93F  M  return                    (data)
. 97F  ctrl Y  return               (code)
```

Note that step (d) illustrates abbreviated versions of the following commands:

```
A90 < 890 . 8AF  M  return          (data)
AB0 < 8B0 . 90F  ctrl Y  return     (code)
B10 < 910 . 93F  M  return          (data)
B40 < 940 . 97F  ctrl Y  return     (code)
```

EXAMPLE 2. Index into Block

Suppose that the program of Example 1 uses an indexed reference into the Data Segment at $890 as follows:

```
LDA  7B0,X
```

where the X-REG is presumed to contain a number in the range $E0 to $FF. Because address $7B0 is outside the Source Block, it will not be relocated. This may be handled in one of two ways.

(a) You may fix the exception by hand; or

(b) You may begin the Block specifications one page lower than the addresses at which the original and relocated programs begin to use all such "early references." One lower page is enough, since FF (the number of bytes in one page) is the largest offset number that the X-REG can contain. In EXAMPLE 1, change step (b) to:

```
900 < 700 . 97F  ctrl Y  *  return
```

Note: with this Block specification, <u>all</u> program references to the "prior page" (in this case the $700 page) will be relocated.

EXAMPLE 3. Immediate Address References

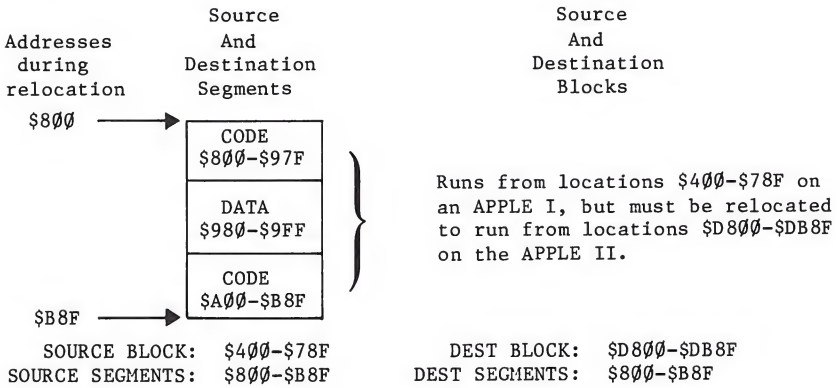
Suppose that the program of EXAMPLE 1 has an immediate reference which is an address. For example,

```
LDA  #$3F
STA  LOCØ
LDA  #$Ø8
STA  LOC1
JMP  (LOCØ)
```

In this example, the LDA #$Ø8 will not be changed during relocation and the user will have to hand-modify it to $ØA.

EXAMPLE 4. Unusable Block Ranges

Suppose a program was written to run from locations $4ØØ-$78F on an APPLE I. A version which will run in ROM locations $D8ØØ-$DB8F must be generated. The Source (and Destination) Segments will reside in locations $8ØØ-$B8F on the APPLE II during relocation.



(a) Initialize the Code-Relocation feature:

reset D4D5G return

(b) Load original program into locations $8ØØ-$B8F (despite the fact that it doesn't run there):

8ØØ . B8F R return

(c) Specify Destination and Source Block parameters (locations from which the original and relocated versions will run):

```
D8ØØ < 4ØØ . 78F  ctrl Y      return
```

(d) Move Data Segments and relocate Code Segments, in ascending address sequence:

```
8ØØ < 8ØØ . 97F  ctrl Y  return          (first segment, code)
. 9FF  M  return                         (data)
. B8F  ctrl Y  return                    (code)
```

Note that because the relocation is done "in place", the SOURCE SEGMENT BEG parameter is the same as the DEST SEGMENT BEG parameter ($8ØØ) and need not be specified. The initial segment relocation command may be abbreviated as follows:

```
8ØØ < . 97F  ctrl Y  return
```

EXAMPLE 5. Changing the Page Zero Variable Allocation

Suppose the program of EXAMPLE 1 need not be relocated, but the page zero variable allocation is from $2Ø to $3F. Because these locations are reserved for the APPLE II system monitor, the allocation must be changed to locations $8Ø-$9F. The Source and Destination Blocks are thus <u>not</u> the program but rather the variable area.

```
   SOURCE BLOCK:  $2Ø-$3F          DEST BLOCK:  $8Ø-$9F
SOURCE SEGMENTS:  $8ØØ-$97F     DEST SEGMENTS:  $8ØØ-$97F
```

(a) Initialize the Code-Relocation feature:

```
reset D4D5G return
```

(b) Specify Destination and Source Blocks:

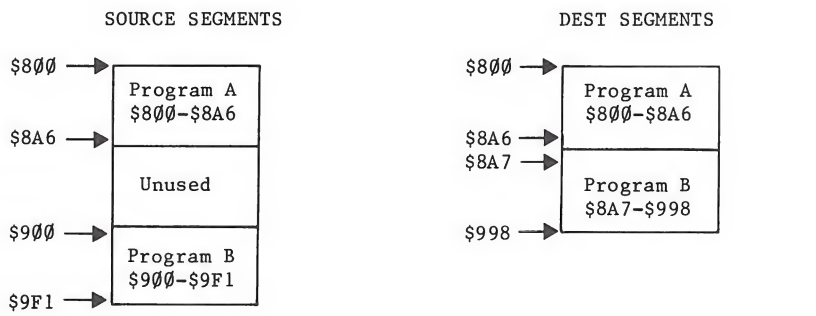
```
8Ø < 2Ø . 3F  ctrl Y  *  return
```

(c) Relocate Code Segments and Move Data Segments, in place:

```
8ØØ < . 88F  ctrl Y  return          (first segment, code)
. 8AF  M  return                     (data)
. 9ØF  ctrl Y  return                (code)
. 93F  M  return                     (data)
. 97F  ctrl Y  return                (code)
```

EXAMPLE 6. Split Blocks with Cross-Referencing

Program A resides and runs in locations $8ØØ-$8A6. Program B resides and runs in locations $9ØØ-$9F1. A single, contiguous program is to be generated by moving Program B so that it immediately follows Program A. Each of the programs contains references to memory locations within the other. It is assumed that the programs contain no Data Segments.



SOURCE BLOCK:	$9ØØ-$9F1	DEST BLOCK:	$8A7-$998
SOURCE SEGMENTS:	$8ØØ-$8A6 (A)	DEST SEGMENTS:	$8ØØ-$8A6 (A)
	$9ØØ-$9F1 (B)		$8A7-$998 (B)

(a) Initialize the Code-Relocation feature:

```
D4D5G return
```

(b) Specify Destination and Source Blocks (Program B only):

```
8A7 < 9ØØ . 9F1  ctrl Y  *  return
```

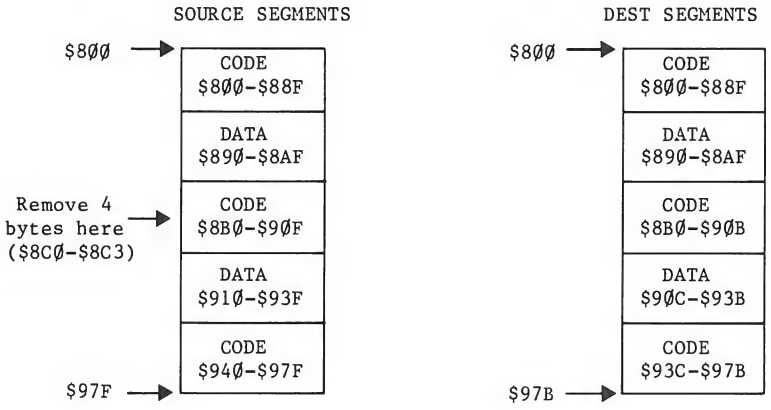
(c) Relocate each of the two programs individually. Program A must be relocated even though it does not move.

```
8ØØ < . 8A6  ctrl Y  return          (program A, "in place")
8A7 < 9ØØ . 9F1  ctrl Y  return      (program B, not "in place")
```

Note that any Data Segments within the two programs would necessitate additional relocation and Move commands.

EXAMPLE 7. Code Deletion

Four bytes of code are to be removed from within a program, and the program is to contract accordingly.



SOURCE BLOCK:	$8C4-$97F	DEST BLOCK:	$8CØ-$97B
SOURCE SEGMENTS:	$8ØØ-$88F (code)	DEST SEGMENTS:	$8ØØ-$88F (code)
	$89Ø-$8AF (data)		$89Ø-$8AF (data)
	$8BØ-$8BF (code)		$8BØ-$8BF (code)
	$8C4-$9ØF (code)		$8CØ-$9ØB (code)
	$91Ø-$93F (data)		$9ØC-$93B (data)
	$94Ø-$97F (code)		$93C-$97B (code)

(a) Initialize Code-Relocation feature:

```
reset D4D5G return
```

(b) Specify Destination and Source Blocks:

```
8CØ < 8C4 . 97F  ctrl Y  *  return
```

(c) Relocate Code Segments and Move Data Segments, in ascending address sequence:

```
8ØØ <. 88F  ctrl Y  return          (first segment, code, "in place")
. 8AF  M  return                        (data)
. 8BF  ctrl Y  return                   (code)
8CØ < 8C4 . 9ØF  ctrl Y  return     (first segment, code, not "in place")
. 93F  M  return                        (data)
. 97F  ctrl Y  return                   (code)
```

(d) Relative branches crossing the deletion boundary will be incorrect, since the relocation process does not modify them (only zero-page and absolute memory references). The user must patch these by hand.

EXAMPLE 8. Relocating the APPLE II Monitor ($F800–$FFFF) to Run in RAM ($800–$FFF)

```
   SOURCE BLOCK:  $F7ØØ-$FFFF              DEST BLOCK:  $7ØØ-$FFF
                        (see EXAMPLE 2)

SOURCE SEGMENTS:  $F8ØØ-$F961 (code)   DEST SEGMENTS:  $8ØØ-$961 (code)
                  $F962-$FA42 (data)                   $962-$A42 (data)
                  $FA43-$FB18 (code)                   $A43-$B18 (code)
                  $FB19-$FB1D (data)                   $B19-$B1D (data)
                  $FB1E-$FFCB (code)                   $B1E-$FCB (code)
                  $FFCC-$FFFF (data)                   $FCC-$FFF (data)

IMMEDIATE ADDRESS REFERENCES (see EXAMPLE 3):    $FFBF
                                                  $FEA8
                                        (more if not relocating
                                           to page boundary)
```

(a) Initialize the Code-Relocation feature:

```
reset D4D5G return
```

(b) Specify Destination and Source Block parameters:

```
7ØØ < F7ØØ . FFFF  ctrl Y  *  return
```

(c) Relocate Code Segments and move Data Segments, in ascending address sequence:

```
8ØØ < F8ØØ . F961  ctrl Y  return          (first segment, code)
. FA42  M  return                          (data)
. FB18  ctrl Y  return                     (code)
. FB1D  M  return                          (data)
. FFCB  ctrl Y  return                     (code)
. FFFF  M  return                          (data)
```

(d) Change immediate address references:

```
FBF : E  return          (was $FE)
EA8 : E  return          (was $FE)
```

PART C: PLOTTING POINTS AND LINES

TECHNICAL INFORMATION

The following details illustrate special technical features of the APPLE II which are used by the Code-Relocation feature.

1. The APPLE II Monitor command

Addr4 < Addr1 . Addr2 ctrl Y return (Addr1, Addr2, and Addr4 are addresses)

vectors to location $3F8 with the value Addr1 in locations $3C (low) and $3D (high), Addr2 in locations $3E (low) and $3F (high), and Addr4 in locations $42 (low) and $43 (high). Location $34 (YSAV) holds an index to the next character of the command buffer (after the ctrl Y). The command buffer (IN) begins at $2ØØ.

2. If ctrl Y is followed by * , then the Block parameters are simply preserved as follows:

Parameter	Preserved at	SWEET16 Reg Name
DEST BLOCK BEG	$8, $9	TOBEG
SOURCE BLOCK BEG	$2, $3	FRMBEG
SOURCE BLOCK END	$4, $5	FRMEND

3. If ctrl Y is not followed by * , then a segment relocation is initiated at RELOC2 ($3BB). Throughout, Addr1 ($3C, $3D) is the Source Segment pointer and Addr4 ($42, $43) is the Destination Segment pointer.

4. INSDS2 is an APPLE II Monitor subroutine which determines the length of a 65Ø2 instruction, given the opcode in the A-REG, and stores that opcode's instruction length in the variable LENGTH (location $2F) .

Instruction Type in A-REG	LENGTH (in $2F)
Invalid	Ø
1 byte	Ø
2 byte	1
3 byte	2

5. The code from XLATE to SW16RT ($3D9-$3E6) uses the APPLE II 16-bit interpretive machine, SWEET16. The target address of the 65Ø2 instruction being relocated (locations $C low and $D high) occupies the SWEET16 register named ADR. If ADR is between FRMBEG and FRMEND (inclusive) then it is replaced by

ADR - FRMBEG + TOBEG

6. NXTA4 is an APPLE II Monitor subroutine which increments Addr1 (Source Segment index) and Addr4 (Destination Segment index). If Addr1 exceeds Addr2 (Source Segment end), then the carry is set; otherwise, it is cleared.

ALGORITHM USED BY THE CODE-RELOCATION FEATURE

1. Set SOURCE PTR to beginning of Source Segment
   and DEST PTR to beginning of Destination Segment.

2. Copy 3 bytes from Source Segment (using SOURCE PTR) to temp INST area.

3. Determine instruction length from opcode (1, 2 or 3 bytes).

4. If two-byte instruction with non-zero-page addressing mode
   (immediate or relative) then go to step 7.

5. If two-byte instruction then clear 3rd byte
   so address field is Ø-255 (zero page).

6. If address field (2nd and 3rd bytes of INST area)
   falls within Source Block, then substitute

   ADR - SOURCE BLOCK BEG + DEST BLOCK BEG

7. Move "length" bytes from INST area to Destination Segment
   (using DEST PTR). Update SOURCE and DEST PTR's by length.

8. If SOURCE PTR is less than or equal to SOURCE SEGMENT END
   then goto step 2., else done.

COMMENTS:

Each Move or relocation is carried out sequentially, one byte at a time, beginning with the byte at the smallest source address. As each source byte is Moved or relocated, it overwrites any information that was in the destination location. This is usually acceptable in these kinds of Moves and relocations:

1. Source Segments and Destination Segments do not share any common locations (no source location is overwritten).

2. Source Segments are in locations identical to the locations of the Destination Segments (each source byte overwrites itself).

3. Source Segments are in locations whose addresses are larger than the addresses of the Destination Segments' locations (any overwritten source bytes have already been Moved or relocated). This is a move toward smaller addresses.

If, however, the Source Segments and the Destination Segments share some common locations, and the Source Segments occupy locations whose addresses are smaller than the addresses of the Destination Segments' locations, then the source bytes occupying the common locations will be overwritten before they are Moved or relocated. If you attempt such a relocation, you will lose your program and data in the memory area common to both Source Segments and Destination Segments. To accomplish a small Move or relocation toward larger addresses, you must Move or relocate to an area of memory well away from the Source Segments (no address in common); then Move the entire relocated program back to its final resting place.

Note: the example instructions in this chapter often include spaces for easier reading; do not type these spaces.

CHAPTER 6
RAM TEST

TESTING THE APPLE'S MEMORY

With this program, you can easily discover any problems in the RAM (for Random Access Memory) chips in your APPLE. This is especially useful when adding new memory. While a failure is a rare occurrence, memory chips are both quite complex and relatively expensive. This program will point out the exact memory chip or chips, if any, that have malfunctioned.

Memory chips are made in two types: one type can store 4K (4Ø96) bits of information, the other can store 16K (16384) bits of information. Odd as it seems, the two types look alike, except for a code number printed on them.

The APPLE has provisions for inserting as many as 24 memory chips of either type into its main printed-circuit board, in three rows of eight sockets each. An eight-bit byte of information consists of one bit taken from each of the eight memory chips in a given row. For this reason, memory can be added only in units of eight identical memory chips at a time, filling an entire row. Eight 4K memory chips together in one row can store 4K bytes of information. Eight 16K memory chips in one row can store 16K bytes of information.

Inside the APPLE II, the three rows of sockets for memory chips are row "C", row "D" and row "E". The rows are lettered along the left edge of the printed-circuit board, as viewed from the front of the APPLE. The memory chips are installed in the third through the tenth sockets (counting from the left) of rows C, D and E. These sockets are labelled "RAM". Row C must be filled; and row E may be filled only if row D is filled. Depending on the configuration of your APPLE's memory, the eight RAM sockets in a given row of memory must be filled entirely with 4K memory chips, entirely with 16K memory chips, or all eight RAM sockets may be empty.

To test the memory chips in your computer, you must first initialize the RAM Test program. Press the RESET key to invoke the Monitor, and then type

```
D5BCG return
```

Next, specify the hexadecimal starting address for the portion of memory that you wish to test. You must also specify the hexadecimal number of "pages" of memory that you wish tested, beginning at the given starting address. A page of memory is 256 bytes ($1ØØ Hex). Representing the address by "a" and the number of pages by "p" (both in hexadecimal), start the RAM test by typing

```
a . p ctrl Y return
```

Note 1: to type "ctrl Y", type Y while holding down the CTRL key; ctrl Y is not displayed on the TV screen. Type "return" by pressing the RETURN key. The example instructions in this chapter often include spaces for easier reading; do not type these spaces.

Note 2: test length p*1ØØ must not be greater than starting address a.

For example,

2000.10 ctrl Y return

tests hexadecimal 1000 bytes of memory (4096, or "4K" bytes, in decimal), starting at hexadecimal address 2000 (8192, or "8K", in decimal).

If the asterisk returns (after a delay that may be a half minute or so) without an error message (see ERROR MESSAGES discussion), then the specified portion of memory has tested successfully.

TABLE OF ADDRESS RANGES FOR STANDARD RAM CONFIGURATIONS

If the 3 Memory Configuration Blocks Look like this:	Then Row of Memory	Contains this Range of Hexadecimal RAM Addresses	And the total System Memory, If this is last Row filled, is
4K	C	0000-0FFF	4K
4K	D	1000-1FFF	8K
4K	E	2000-2FFF	12K
16K	C	0000-3FFF	16K
4K	D	4000-4FFF	20K
4K	E	5000-5FFF	24K
16K	C	0000-3FFF	16K
16K	D	4000-7FFF	32K
16K	E	8000-BFFF	48K

A 4K RAM Row contains 10 Hex pages (hex 1000 bytes, or decimal 4096 bytes). A 16K RAM Row contains 40 Hex pages (hex 4000 bytes, or decimal 16384 bytes).

A complete test for a 48K system would be as follows:

```
 400.4  ctrl Y return  <---- This tests the screen area of memory
 800.8  ctrl Y return  <---- These first four tests examine
1000.10 ctrl Y return  <----          the first 16K row of memory  (Row C)
2000.20 ctrl Y return  <----
4000.40 ctrl Y return  <---- This tests the second 16K row of memory (Row D)
8000.40 ctrl Y return  <---- This tests the third 16K row of memory  (Row E)
```

Systems containing more than 16K of memory should also receive the following special test that looks for problems at the boundary between rows of memory:

3000.20 ctrl Y return

Systems containing more than 32K of memory should receive the previous special test, plus the following:

7000.20 ctrl Y return

Tests may be run separately or they may be combined into one instruction. For instance, for a 48K system you can type:

4ØØ.4 ctrl Y 8ØØ.8 ctrl Y 1ØØØ.1Ø ctrl Y 2ØØØ.2Ø ctrl Y 3ØØØ.2Ø ctrl Y 4ØØØ.4Ø ctrl Y 7ØØØ.2Ø ctrl Y 8ØØØ.4Ø ctrl Y return

Remember, ctrl Y will not print on the screen, but it must be typed. With the single exception noted in the section TESTING FOR INTERMITTENT FAILURE, spaces are shown for easier reading but should not be typed.

During a full test such as the one shown above, the computer will beep at the completion of each sub-test (each sub-test ends with a ctrl Y). At the end of the full test, if no errors have been found the APPLE will beep and the blinking cursor will return with the Monitor prompt character (*). It takes approximately 5Ø seconds for the computer to test the RAM memory in a 16K system; larger systems will take proportionately longer.

ERROR MESSAGES

TYPE I - Simple Error

During testing, each memory address in the test range is checked by writing a particular number to it, then reading the number actually stored at that address and comparing the two.

A simple error occurs when the number written to a particular memory address differs from the number which is then read back from that same address. Simple errors are reported in the following format:

xxxx yy zz ERR r-c

where xxxx is the hexadecimal address at which the error was detected;
yy is the hexadecimal data written to that address;
zz is the hexadecimal data read back from that address; and
r-c is the row and column where the defective memory chip was found. Count from the left, as viewed from the front of the APPLE: the leftmost memory chip is in column 3, the rightmost is in column 1Ø.

Example:

2Ø1F ØØ 1Ø ERR D-7

TYPE II - Dynamic Error

This type of error occurs when the act of writing a number to one memory address causes the number read from a different address to change. If no simple error is detected at a tested address, all the addresses that differ from the tested address by one bit are read for changes indicating dynamic errors. Dynamic errors are reported in the following format:

xxxx yy zz vvvv qq ERR r-c

where xxxx is the hexadecimal address at which the error was detected;
yy is the hexadecimal data written earlier to address xxxx;
zz is the hexadecimal data now read back from address xxxx;
vvvv is the current hexadecimal address to which data qq was successfully written;
qq is the hexadecimal data successfully written to, and read back from, address vvvv; and
r-c is the row and column where the defective memory chip was found. Count from the left, as viewed from the front of the APPLE: the leftmost memory chip is in column 3, the rightmost is in column 1Ø. In this type of error, the indicated row (but not the column) may be incorrect.

This is similar to Type I, except that the appearance of vvvv and qq indicates an error was detected at address xxxx after data was successfully written at address vvvv.

Example:

5Ø51 ØØ Ø8 5451 ØØ ERR E-6

After a dynamic error, the indicated row (but not the column) may be incorrect. Determine exactly which tests check each row of chips (according to the range of memory addresses corresponding to each row), and run those tests by themselves. Confirm your diagnosis by replacing the suspected memory chip with a known good memory chip (you can use either a 4K or a 16K memory chip, for this replacement). Remember to turn off the APPLE's power switch and to discharge yourself before handling the memory chips.

TESTING FOR INTERMITTENT FAILURE (Automatically Repeating Test)

This provides a way to test memory over and over again, indefinitely. You will type a complete series of tests, just as you did before, except that you will:

a. precede the complete test with the letter N
b. follow the complete test with 34:Ø
c. type at least one space before pressing the RETURN key.

Here is the format:

N (memory test to be repeated) 34:Ø (type one space) return

NOTE: You must type at least one space at the end of the line, prior to pressing the RETURN key. This is the only space that should be typed (all other spaces shown within instructions in this chapter are for easier reading only; they should not be typed).

Example (for a 48K system):

N 4ØØ.4 ctrl Y 8ØØ.8 ctrl Y 1ØØØ.1Ø ctrl Y 2ØØØ.2Ø ctrl Y 3ØØØ.2Ø ctrl Y 4ØØØ.4Ø ctrl Y 7ØØØ.2Ø ctrl Y 8ØØØ.4Ø ctrl Y 34:Ø return

Run this test for at least one hour (preferably overnight) with the APPLE's lid in place. This allows the system and the memory chips to reach maximum operating temperature.

Only if a failure occurs will the APPLE display an error message and rapidly beep three times; otherwise, the APPLE will beep once at the successful end of each sub-test. To stop this repeating test, you must press the RESET key.

COMMENTS:

1. You cannot test the APPLE's memory below the address of 4ØØ (Hex), since various pointers and other system necessities are there. In any case, if that region of memory has problems, the APPLE won't function.

2. For any subtest, the number of pages tested cannot be greater than the starting address divided by 1ØØ Hex. 2ØØØ.3Ø ctrl Y will not work, but 5ØØØ.3Ø ctrl Y will.

3. Before changing anything inside the APPLE, make sure the APPLE is plugged into a grounded, 3-wire power outlet, and that the power switch on the back of the computer is turned off. Always touch the outside metal bottom plate of the APPLE II, prior to handling any memory chips. This is done to remove any static charge that you may have acquired.

EVEN A SMALL STATIC CHARGE CAN DESTROY MEMORY CHIPS

4. Besides the eight memory chips, some additions of memory require changing three other chip-like devices called Memory Configuration Blocks. The Memory Configuration Blocks tell the APPLE which type of memory chip (4K or 16K) is to be plugged into each row of memory. A complete package for adding memory to your computer, containing all necessary parts and detailed instructions, can be purchased from APPLE Computer Inc. To add 4K of memory, order the 4K Memory Expansion Module (P/N A2MØØ14). To add 16K of memory, order the 16K Memory Expansion Module (P/N A2MØØ16).

CHAPTER 7
MUSIC

GENERATING MUSICAL TONES

The Music feature is most easily used from within an Integer BASIC program. It greatly simplifies the task of making the APPLE II into a music-playing device.

There are three things the computer needs to know before playing a note: pitch (how high or low a note), duration (how long a time it is to sound), and timbre. Timbre is the quality of a sound that allows you to distinguish one instrument from another even if they are playing at the same pitch and loudness. This Music feature does not permit control of loudness.

It is convenient to set up a few constants early in the program:

```
MUSIC = -1Ø473
PITCH = 767
TIME = 766
TIMBRE = 765
```

There are 5Ø notes available, numbered from 1 to 5Ø. The statement

```
POKE PITCH, 32
```

will set up the Music feature to produce (approximately) the note middle C. Increasing the pitch value by one increases the pitch by a semitone. Thus

```
POKE PITCH, 33
```

would set up the Music feature to produce the note C sharp. Just over four chromatic octaves are available. The note number Ø indicates a rest (a silence) rather than a pitch.

The duration of the note is set by

```
POKE TIME, t
```

Where t is a number from 1 to 255. The higher the number, the longer the note. A choice of t = 17Ø gives notes that are approximately one second long. To get notes at a metronome marking of MM, use a duration of 1Ø2ØØ/MM. For example, to get 2Ø4 notes per minute (approximately) use the command

```
POKE TIME, 1Ø2ØØ/2Ø4
```

There are five timbres, coded by the numbers 2, 8, 16, 32 and 64. They are not very different from one another. With certain timbres, a few of the extremely low or high notes do not give the correct pitch. Timbre 32 does not have this problem.

```
POKE TIMBRE, 32
```

When the pitch, time, and timbre have been set, the statement

```
CALL MUSIC
```

will cause the specified note to sound.

The following program plays a chromatic scale of four octaves:

```
1Ø MUSIC = -1Ø473: PITCH = 767: TIME = 766: TIMBRE = 765
2Ø POKE TIME, 4Ø: POKE TIMBRE, 32
3Ø FOR I = 1 TO 49
4Ø POKE PITCH, I
5Ø CALL MUSIC
6Ø NEXT I: END
```

Where X is a number from 51 through 255,

```
POKE PITCH, X
```

will specify various notes, in odd sequences. In the program above, change line 4Ø to

```
4Ø POKE PITCH, 86
```

for a demonstration.

COMMENTS:

Some extremely high or low notes will come out at the wrong pitch with certain timbres.

CHAPTER 8
HIGH-RESOLUTION GRAPHICS

PART A: SETTING UP PARAMETERS, SUBROUTINES, AND COLORS

Programmer's Aid #1 provides your APPLE with the ability to do high-resolution color graphics from Integer BASIC. You may plot dots, lines and shapes in a wide variety of detailed forms, in 6 different colors (4 colors on systems below S/N 6ØØØ), displayed from two different "pages" of memory. The standard low-resolution graphics allowed you to plot 4Ø squares across the screen by 47 squares from top to bottom of the screen. This high-resolution graphics display mode lets you plot in much smaller dots, 28Ø horizontally by 192 vertically. Because 8K bytes of memory (in locations from 8K to 16K, for Page 1) are dedicated solely to maintaining the high-resolution display, your APPLE must contain at least 16K bytes of memory. To use the Page 2 display (in locations from 16K to 24K), a system with at least 24K bytes of memory is needed. If your system is using the Disk Operating System (DOS), that occupies the top 1Ø.5K of memory: you will need a minimum 32K system for Page 1, or 36K for Page 1 and Page 2. See the MEMORY MAP on page 63 for more details.

POSITIONING THE HIGH-RESOLUTION PARAMETERS

The first statement of an Integer BASIC program intending to use the Programmer's Aid High-Resolution subroutines should be:

```
Ø  XØ = YØ = COLR = SHAPE = ROT = SCALE
```

The purpose of this statement is simply to place the six BASIC variable names used by the High-Resolution feature (with space for their values) into APPLE's "variable table" in specific, known locations. When line Ø is executed, the six High-Resolution graphics parameters will be assigned storage space at the very beginning of the variable table, in the exact order specified in line Ø. Your BASIC program then uses those parameter names to change the six parameter values in the variable table. However, the High-Resolution subroutines ignore the parameter names, and look for the parameter values in specific variable-table locations. That is why the program's first line must place the six High-Resolution graphics parameters in known variable-table locations. Different parameter names may be used, provided that they contain the same number of characters. Fixed parameter-name lengths are also necessary to insure that the parameter-value storage locations in the variable table do not change. For example, the name HI could be used in place of XØ, but X or XCOORD could not.

The parameters SHAPE, ROT, and SCALE are used only by the subroutines that draw shapes (DRAW and DRAW1, see PART E). These parameters may be omitted from programs using only the PLOT and LINE features:

```
Ø  XØ = YØ = COLR
```

Omitting unnecessary parameter definitions speeds up the program during execution. However, you can omit only those unused parameters to the right of the last parameter which is used. Each parameter that is used must be in its proper place, relative to the first parameter in the definition list.

DEFINING SUBROUTINE NAMES

After the six parameters have been defined, the twelve High-Resolution subroutines should be given names, and these names should be assigned corresponding subroutine entry addresses as values. Once defined in this way, the various subroutines can be called by name each time they are used, rather than by numeric address. When subroutines are called by name, the program is easier to type, more likely to be error-free, and easier to follow and to debug.

```
5  INIT = -12288  : CLEAR = -12274 : BKGND = -11471
6  POSN = -11527  : PLOT = -115Ø6  : LINE = -115ØØ
7  DRAW = -11465  : DRAW1 = -11462
8  FIND = -1178Ø : SHLOAD = -11335
```

Any variable names of any length may be used to call these subroutines. If you want maximum speed, do not define names for subroutines that you will not use in your program.

DEFINING COLOR NAMES

Colors may also be specified by name, if a defining statement is added to the program. Note that GREEN is preceded by LET to avoid a SYNTAX ERROR, due to conflict with the GR command.

```
1Ø  BLACK = Ø : LET GREEN = 42 : VIOLET = 85
11  WHITE = 127 ORANGE = 17Ø BLUE = 213
12  BLACK2 = 128 WHITE2 = 255
```

Any integer from Ø through 255 may be used to specify a color, but most of the numbers not named above give rather unsatisfactory "colors". On systems below S/N 6ØØØ, 17Ø will appear as green and 213 will appear as violet.

Once again, unnecessary variable definitions should be omitted, as they will slow some programs. Therefore, a program should not define VIOLET = 85 unless it uses the color VIOLET.

The following example illustrates condensed initialization for a program using only the INIT, PLOT, and DRAW subroutines, and the colors GREEN and WHITE.

```
Ø  XØ = YØ = COLR = SHAPE = ROT = SCALE
5  INIT = -12288 : PLOT = -115Ø6 : DRAW = -11465
1Ø  LET GREEN = 42 : WHITE = 127

    (Body of program would go here)
```

SPEEDING UP YOUR PROGRAM

Where maximum speed of execution is necessary, any of the following techniques will help:

1. Omit the name definitions of colors and subroutines, and refer to colors and subroutines by numeric value, not by name.

2. Define the most frequently used program variable names before defining the subroutine and color names (lines 5 through 12 in the previous examples). The example below illustrates how to speed up a program that makes very frequent use of program variables I, J, and K:

```
Ø  XØ = YØ = COLR = SHAPE = ROT = SCALE
2  I = J = K
5  INIT = -12288 : CLEAR = -12274
6  BKGND = -11471 : POSN = -11527
1Ø  BLACK = Ø : VIOLET = 85
```

3. Use the High-Resolution graphics parameter names as program variables when possible. Because they are defined first, these parameters are the BASIC variables which your program can find fastest.

PART B: PREPARING THE SCREEN FOR GRAPHICS

THE INITIALIZATION SUBROUTINE

In order to use CLEAR, BKGND, POSN, PLOT, or any of the other High-Resolution subroutine CALLs, the INITialization subroutine itself must first be CALLed:

```
CALL INIT
```

The INITialization subroutine turns on the high-resolution display and clears the high-resolution screen to black. INIT also sets up certain variables necessary for using the other High-Resolution subroutines. The display consists of a graphics area that is 28Ø x-positions wide (XØ=Ø through XØ=279) by 16Ø y-positions high (YØ=Ø through YØ=159), with an area for four lines of text at the bottom of the screen. YØ values from Ø through 191 may be used, but values greater than 159 will not be displayed on the screen. The graphics origin (XØ=Ø, YØ=Ø) is at the top left corner of the screen.

CHANGING THE GRAPHICS SCREEN

If you wish to devote the entire display to graphics (28Ø x-positions wide by 192 y-positions high), use

```
POKE -163Ø2, Ø
```

The split graphics-plus-text mode may be restored at any time with

```
POKE -163Ø1, Ø
```

or another

```
CALL INIT
```

When the High-Resolution subroutines are first initialized, all graphics are done in Page 1 of memory ($2ØØØ-3FFF), and only that page of memory is displayed. If you wish to use memory Page 2 ($4ØØØ-5FFF), two POKEs allow you to do so:

```
POKE 8Ø6, 64
```

causes subsequent graphics instructions to be executed in Page 2, unless those instructions attempt to continue an instruction from Page 1 (for instance, a LINE is always drawn on the same memory page where the last previous point was plotted). After this POKE, the display will still show memory Page 1.

To see what you are plotting on Page 2,

```
POKE -16299, Ø
```

will cause Page 2 to be displayed on the screen. You can switch the screen display back to memory Page 1 at any time, with

```
POKE -163ØØ, Ø
```

while

```
POKE 8Ø6, 32
```

will return you to Page 1 plotting. This last POKE is executed automatically by INIT.

CLEARING THE SCREEN

If at any time during your program you wish to clear the current plotting page to black, use

```
CALL CLEAR
```

This immediately erases anything plotted on the current plotting page. INIT first resets the current plotting page to memory Page 1, and then clears Page 1 to black.

The entire current plotting page can be set to any solid background color with the BKGND subroutine. After you have INITialized the High-Resolution subroutines, set COLR to the background color you desire, and then

```
CALL BKGND
```

The following program turns the entire display violet:

```
Ø  XØ = YØ = COLR : REM  SET PARAMETERS
5  INIT = -12288 : BKGND = -11471 : REM  DEFINE SUBROUTINES
1Ø  VIOLET = 85 : REM  DEFINE COLOR
2Ø  CALL INIT : REM  INITIALIZE HIGH-RESOLUTION SUBROUTINES
3Ø  COLR = VIOLET : REM  ASSIGN COLOR VALUE
4Ø  CALL BKGND : REM  MAKE ALL OF DISPLAY VIOLET
5Ø  END
```

PART C: PLOTTING POINTS AND LINES

Points can be plotted anywhere on the high-resolution display, in any valid color, with the use of the PLOT subroutine. The PLOT subroutine can only be used after a CALL INIT has been executed, and after you have assigned appropriate values to the parameters XØ, YØ and COLR. XØ must in the range from Ø through 279, YØ must be in the range from Ø through 191, and COLR must be in the range from Ø through 255, or a

```
*** RANGE ERR
```

message will be displayed and the program will halt.

The program below plots a white dot at X-coordinate 35, Y-coordinate 55, and a violet dot at X-coordinate 85, Y-coordinate 9Ø:

```
Ø  XØ = YØ = COLR : REM  SET PARAMETERS
5  INIT = -12288 : PLOT = -11506 : REM  DEFINE SUBROUTINES
1Ø  WHITE = 127 : VIOLET = 85 : REM  DEFINE COLORS
2Ø  CALL INIT : REM  INITIALIZE SUBROUTINES
3Ø  COLR = WHITE : REM  ASSIGN PARAMETER VALUES
4Ø  XØ = 35 : YØ = 55
5Ø  CALL PLOT : REM  PLOT WITH ASSIGNED PARAMETER VALUES
6Ø  COLR = VIOLET : REM  ASSIGN NEW PARAMETER VALUES
7Ø  XØ = 85 : YØ = 9Ø
8Ø  CALL PLOT : REM  PLOT WITH NEW PARAMETER VALUES
9Ø  END
```

The subroutine POSN is exactly like PLOT, except that nothing is placed on the screen. COLR must be specified, however, and a subsequent DRAW1 (see PART E) will take its color from the color used by POSN. This subroutine is often used when establishing the origin-point for a LINE.

Connecting any two points with a straight line is done with the LINE subroutine. As with the PLOT subroutine, a CALL INIT must be executed, and XØ, YØ, and COLR must be specified. In addition, before the LINE subroutine can be CALLed, the line's point of origin must have been plotted with a CALL PLOT or as the end point of a previous line or shape. Do not attempt to use CALL LINE without first plotting a point for the line's origin, or the line may be drawn in random memory locations, not necessarily restricted to the current memory page. Once again, XØ and YØ (the coordinates of the termination point for the line), and COLR must be assigned legitimate values, or an error may occur.

The following program draws a grid of green lines vertically and violet lines horizontally, on a white background:

```
Ø  XØ = YØ = COLR : REM  SET PARAMETERS, THEN DEFINE SUBROUTINES
5  INIT = -12288 : BKGND = -11471 : PLOT = -115Ø6 : LINE = -115ØØ
1Ø  LET GREEN = 42 : VIOLET = 85 : WHITE = 127 : REM DEFINE COLORS
2Ø  CALL INIT : REM  INITIALIZE HIGH-RESOLUTION SUBROUTINES
3Ø  POKE -163Ø2, Ø : REM  SET FULL-SCREEN GRAPHICS
4Ø  COLR = WHITE : CALL BKGND : REM  MAKE THE DISPLAY ALL WHITE
5Ø  COLR = GREEN : REM  ASSIGN PARAMETER VALUES
6Ø  FOR XØ = Ø TO 27Ø STEP 1Ø
7Ø  YØ = Ø : CALL PLOT : REM  PLOT A STARTING-POINT AT TOP OF SCREEN
8Ø  YØ = 19Ø : CALL LINE : REM  DRAW A VERTICAL LINE TO BOTTOM OF SCREEN
9Ø  NEXT XØ : REM  MOVE RIGHT AND DO IT AGAIN
1ØØ  COLR = VIOLET : REM  ASSIGN NEW PARAMETER VALUES
11Ø  FOR YØ = Ø TO 19Ø STEP 1Ø
12Ø  XØ = Ø : CALL PLOT : REM  PLOT A STARTING-POINT AT LEFT EDGE OF SCREEN
13Ø  XØ = 27Ø : CALL LINE : REM  PLOT A HORIZONTAL LINE TO RIGHT EDGE
14Ø  NEXT YØ : REM  MOVE DOWN AND DO IT AGAIN
15Ø  END
```

PART D: CREATING, SAVING AND LOADING SHAPES

INTRODUCTION

The High-Resolution feature's subroutines provide the ability to do a wide range of high-resolution graphics "shape" drawing. A "shape" is considered to be any figure or drawing (such as an outline of a rocket ship) that the user wishes to draw on the display many times, perhaps in different sizes, locations and orientations. Up to 255 different shapes may be created, used, and saved in a "Shape Table", through the use of the High-Resolution subroutines DRAW, DRAW1 and SHLOAD, in conjunction with parameters SHAPE, ROT and SCALE.

In this section, PART D, you will be shown how to create, save and load a Shape Table. The following section, PART E, demonstrates the use of the shape-drawing subroutines with a predefined Shape Table.

HOW TO CREATE A SHAPE TABLE

Before the High-Resolution shape-drawing subroutines can be used, a shape must be defined by a "shape definition." This shape definition consists of a sequence of plotting vectors that are stored in a series of bytes in APPLE's memory. One or more such shape definitions, with their index, make up a "Shape Table" that can be created from the keyboard and saved on disk or cassette tape for future use.

Each byte in a shape definition is divided into three sections, and each section can specify a "plotting vector": whether or not to plot a point, and also a direction to move (up, down, left, or right). The shape-drawing subroutines DRAW and DRAW1 (see PART E) step through each byte in the shape definition section by section, from the definition's first byte through its last byte. When a byte that contains all zeros is reached, the shape definition is complete.

This is how the three sections A, B and C are arranged within one of the bytes that make up a shape definition:

Section:	C		B			A		
Bit Number:	7	6	5	4	3	2	1	Ø
Specifies:	D	D	P	D	D	P	D	D

Each bit pair DD specifies a direction to move, and each bit P specifies whether or not to plot a point before moving, as follows:

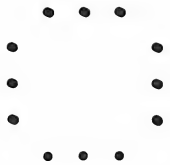
```
If DD = ØØ  move up
      = Ø1  move right          If P = Ø  don't plot
      = 1Ø  move down                 = 1  do plot
      = 11  move left
```

Notice that the last section, C (the two most significant bits), does not have a P field (by default, P=Ø), so section C can only specify a move without plotting.

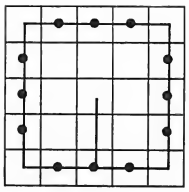
Each byte can represent up to three plotting vectors, one in section A, one in section B, and a third (a move only) in section C.

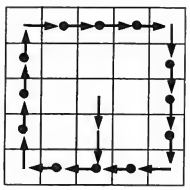
DRAW and DRAW1 process the sections from right to left (least significant bit to most significant bit: section A, then B, then C). At any section in the byte, IF ALL THE REMAINING SECTIONS OF THE BYTE CONTAIN ONLY ZEROS, THEN THOSE SECTIONS ARE IGNORED. Thus, the byte cannot end with a move in section C of ØØ (a move up, without plotting) because that section, containing only zeros, will be ignored. Similarly, if section C is ØØ (ignored), then section B cannot be a move of ØØØ as that will also be ignored. And a move of ØØØ in section A will end your shape definition unless there is a 1-bit somewhere in section B or C.

Suppose you want to draw a shape like this:



First, draw it on graph paper, one dot per square. Then decide where to start drawing the shape. Let's start this one at the center. Next, draw a path through each point in the shape, using only 9Ø degree angles on the turns:





Next, re-draw the shape as a series of plotting vectors, each one moving one place up, down, right, or left, and distinguish the vectors that plot a point before moving (a dot marks vectors that plot points).

Now "unwrap" those vectors and write them in a straight line:

Next draw a table like the one in Figure 1, below:

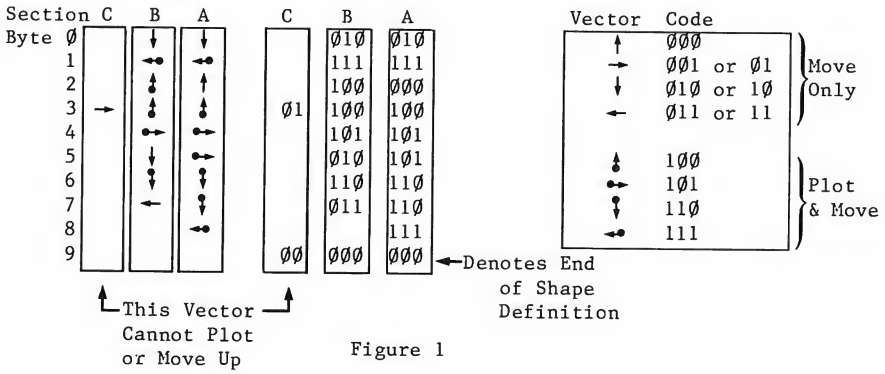


Figure 1

For each vector in the line, determine the bit code and place it in the next available section in the table. If the code will not fit (for example, the vector in section C can't plot a point), or is a ØØ (or ØØØ) at the end of a byte, then skip that section and go on to the next. When you have finished coding all your vectors, check your work to make sure it is accurate.

Now make another table, as shown in Figure 2, below, and re-copy the vector codes from the first table. Recode the vector information into a series of hexadecimal bytes, using the hexadecimal codes from Figure 3.

Section:	C		B			A				Bytes Recoded in Hex	
Byte Ø	Ø	Ø	Ø	1	Ø	Ø	1	Ø	=	1	2
1	Ø	Ø	1	1	1	1	1	1	=	3	F
2	Ø	Ø	1	Ø	Ø	Ø	Ø	Ø	=	2	Ø
3	Ø	1	1	Ø	Ø	1	Ø	Ø	=	6	4
4	Ø	Ø	1	Ø	1	1	Ø	1	=	2	D
5	Ø	Ø	Ø	1	Ø	1	Ø	1	=	1	5
6	Ø	Ø	1	1	Ø	1	1	Ø	=	3	6
7	Ø	Ø	Ø	1	1	1	1	Ø	=	1	E
8	Ø	Ø	Ø	Ø	Ø	1	1	1	=	Ø	7
9	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	=	Ø	Ø ← Denotes End of Shape Definition
Hex:	Digit 1				Digit 2						

Figure 2

Codes		
Binary		Hex
ØØØØ	=	Ø
ØØØ1	=	1
ØØ1Ø	=	2
ØØ11	=	3
Ø1ØØ	=	4
Ø1Ø1	=	5
Ø11Ø	=	6
Ø111	=	7
1ØØØ	=	8
1ØØ1	=	9
1Ø1Ø	=	A
1Ø11	=	B
11ØØ	=	C
11Ø1	=	D
111Ø	=	E
1111	=	F

Figure 3

The series of hexadecimal bytes that you arrived at in Figure 2 is the shape definition. There is still a little more information you need to provide before you have a complete Shape Table. The form of the Shape Table, complete with its index, is shown in Figure 4 on the next page.

For this example, your index is easy: there is only one shape definition. The Shape Table's starting location, whose address we have called S, must contain the number of shape definitions (between Ø and 255) in hexadecimal. In this case, that number is just one. We will place our shape definition immediately below the index, for simplicity. That means, in this case, the shape definition will start in byte S+4: the address of shape definition #1, relative to S, is 4 (ØØ Ø4, in hexadecimal). Therefore, index byte S+2 must contain the value Ø4 and index byte S+3 must contain the value ØØ. The completed Shape Table for this example is shown in Figure 5 on the next page.

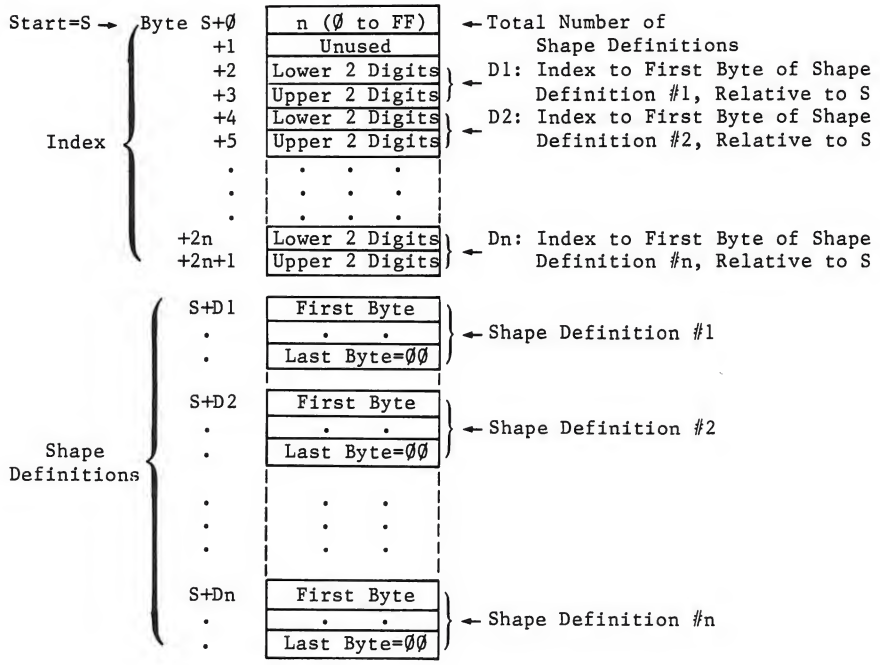


Figure 4

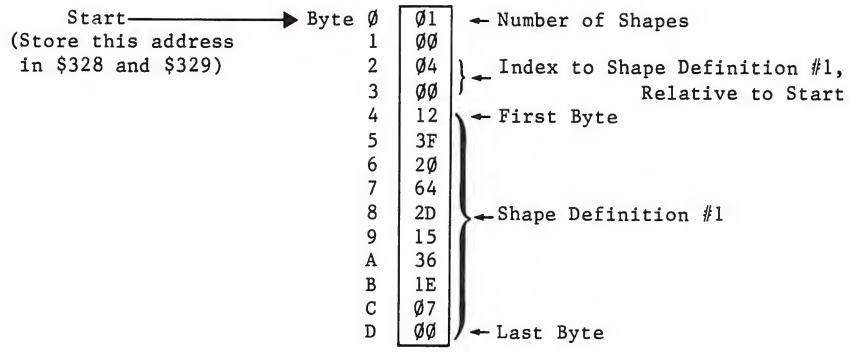


Figure 5

You are now ready to type the Shape Table into APPLE's memory. First, choose a starting address. For this example, we'll use hexadecimal address Ø8ØØ.

Note: this address must be less than the highest memory address available in your system (HIMEM), and not in an area that will be cleared when you use memory Page 1 (hexadecimal locations $2ØØØ to $4ØØØ) or Page 2 (hexadecimal locations $4ØØØ to $6ØØØ) for high-resolution graphics. Furthermore, it must not be in an area of memory used by your BASIC program. Hexadecimal Ø8ØØ (2Ø48, in decimal) is the lowest memory address normally available to a BASIC program. This lowest address is called LOMEM. Later on, we will move the LOMEM pointer higher, to the end of our Shape Table, in order to protect our table from BASIC program variables.

Press the RESET key to enter the Monitor program, and type the Starting address for your Shape Table:

```
Ø8ØØ
```

If you press the RETURN key now, APPLE will show you the address and the contents of that address. That is how you examine an address to see if you have a put the correct number there. If instead you type a colon (:) followed by a two-digit hexadecimal number, that number will be stored at the specified address when you press the RETURN key. Try this:

```
Ø8ØØ return
```

(type "return" by pressing the RETURN key). What does APPLE say the contents of location Ø8ØØ are? Now try this:

```
Ø8ØØ:Ø1 return
Ø8ØØ return
Ø8ØØ- Ø1
```

The APPLE now says that the value Ø1 (hexadecimal) is stored in the location whose address is Ø8ØØ. To store more two-digit hexadecimal numbers in successive bytes in memory, just open the first address:

```
Ø8ØØ:
```

and then type the numbers, separated by spaces:

```
Ø8ØØ:Ø1 ØØ Ø4 ØØ 12 3F 2Ø 64 2D 15 36 1E Ø7 ØØ return
```

You have just typed your first complete Shape Table...not so bad, was it? To check the information in your Shape Table, you can examine each byte separately or simply press the RETURN key repeatedly until all the bytes of interest (and a few extra, probably) have been displayed:

```
 Ø8ØØ return
Ø8ØØ- Ø1
 return
 ØØ Ø4 ØØ 12 3F 2Ø 64
 return
Ø8Ø8- 2D 15 36 1E Ø7 ØØ FF FF
```

If your Shape Table looks correct, all that remains is to store the starting address of the Shape Table where the shape-drawing subroutines can find it (this is done automatically when you use the SHLOAD subroutine to get a table from cassette tape). Your APPLE looks for the four hexadecimal digits of the table's starting address in hexadecimal locations 328 (lower two digits) and 329 (upper two digits). For our table's starting address of Ø8 ØØ, this would do the trick:

```
 328:ØØ Ø8
```

To protect this Shape Table from being erased by the variables in your BASIC program, you must also set LOMEM (the lowest memory address available to your program) to the address that is one byte beyond the Shape Table's last, or largest, address.

It is best to set LOMEM from BASIC, as an immediate-execution command issued before the BASIC program is RUN. LOMEM is automatically set when you invoke BASIC (reset ctrl B return) to decimal 2Ø48 (Ø8ØØ, in hexadecimal). You must then change LOMEM to 2Ø48 plus the number of bytes in your Shape Table plus one. Our Shape Table was decimal 14 bytes long, so our immediate-execution BASIC command would be:

```
LOMEM: 2Ø48 + 15
```

Fortunately, all of this (entering the Shape Table at LOMEM, resetting LOMEM to protect the table, and putting the table's starting address in $328-$329) is taken care of automatically when you use the High-Resolution feature's SHLOAD subroutine to get the table from cassette tape.

SAVING A SHAPE TABLE

Saving on Cassette Tape

To save your Shape Table on tape, you must be in the Monitor and you must know three hexadecimal numbers:

1) Starting Address of the table (Ø8ØØ, in our example)
2) Last Address of the table (Ø8ØD, in our example)
3) Difference between 2) and 1) (ØØØD, in our example)

Item 3, the difference between the last address and the first address of the table, must be stored in hexadecimal locations Ø (lower two digits) and 1 (upper two digits):

```
Ø:ØD ØØ  return
```

Now you can "Write" (store on cassette) first the table length that is stored in locations Ø and 1, and then the Shape Table itself that is stored in locations Starting Address through Last Address:

```
Ø.1W    Ø8ØØ.Ø8ØDW
```

Don't press the RETURN key until you have put a cassette in your tape recorder, rewound it, and started it recording (press PLAY and RECORD simultaneously). Now press the computer's RETURN key.

Saving on Disk

To save your Shape Table on disk, use a command of this form:

```
BSAVE filename, A$ startingaddress, L$ tablelength
```

For our example, you might type

```
BSAVE MYSHAPE1, A$ Ø8ØØ, L$ ØØØD
```

Note: the Disk Operating System (DOS) occupies the top 1Ø.5K of memory (1Ø752 bytes decimal, or $2AØØ hex); make sure your Shape Table is not in that portion of memory when you "boot" the disk system.

LOADING A SHAPE TABLE

Loading from Cassette Tape

To load a Shape Table from cassette tape, rewind the tape, start it playing (press PLAY), and (in BASIC, now) type

```
CALL -11335 return
```

or (if you have previously assigned the value -11335 to the variable SHLOAD)

```
CALL SHLOAD return
```

You should hear one "beep" when the table's length has been read successfully, and another "beep" when the table itself has been read. When loaded this way, your Shape Table will load into memory, beginning at hexadecimal address Ø8ØØ. LOMEM is automatically changed to the address of the location immediately following the last Shape-Table byte. Hexadecimal locations 328 and 329 are automatically set to contain the starting address of the Shape Table.

Loading from Disk

To load a Shape Table from disk, use a command of the form

```
BLOAD filename
```

From our previously-saved example, you would type

```
BLOAD MYSHAPE1
```

This will load your Shape Table into memory, beginning at the address you specified after "A$" when you BSAVEd the Shape Table earlier. In our example, MYSHAPE1 would BLOAD beginning at address Ø8ØØ. You must store the Shape Table's starting address in hexadecimal locations 328 and 329, yourself, from the Monitor:

```
328:ØØ Ø8 return
```

If your Shape Table is in an area of memory that may be used by your BASIC program (as our example is), you must protect the Shape Table from your program. Our example lies at the low end of memory, so we can protect it by raising LOMEM to just above the last byte of the Shape Table. This must be done after invoking BASIC (reset ctrl B return) and before RUNning our BASIC program. We could do this with the immediate-execution BASIC command

```
LOMEM: 2Ø48 + 15
```

FIRST USE OF A SHAPE TABLE

You are now ready to write a BASIC program using Shape-Table subroutines such as DRAW and DRAW1. For a full discussion of these High-Resolution subroutines, see the following section, PART E.

Remember that Page 1 graphics uses memory locations 8192 through 16383 (8K to 16K), and Page 2 graphics uses memory locations 16384 through 24575 (16K to 24K). Integer BASIC puts your program right at the top of available memory; so if your APPLE contains less than 32K of memory, you should protect your program by setting HIMEM to 8192. This must be done after you invoke BASIC (reset ctrl B return) and before RUNning your program, with the immediate-execution command

```
HIMEM: 8192
```

Here's a sample program that assumes our Shape Table has already been loaded from tape, using CALL SHLOAD. This program will print our defined shape, rotate it 5.6 degrees if that rotation is recognized (see ROT discussion, next section) and then repeat, each repetition larger than the one before.

```
1Ø  XØ = YØ = COLR = SHAPE = ROT = SCALE : REM  SET PARAMETERS
2Ø  INIT = -12288 : DRAW = -11465 : REM  DEFINE SUBROUTINES
3Ø  WHITE = 127 : BLACK = Ø : REM  DEFINE COLORS
4Ø  CALL INIT : REM  INITIALIZE HIGH-RESOLUTION SUBROUTINES
5Ø  SHAPE = 1
6Ø  XØ = 139 : YØ = 79 : REM  ASSIGN PARAMETER VALUES
7Ø  FOR R = 1 TO 48
8Ø  ROT = R
9Ø  SCALE = R
1ØØ  COLR = WHITE
11Ø  CALL DRAW : REM  DRAW SHAPE 1 WITH ABOVE PARAMETERS
12Ø  NEXT R : REM  NEW PARAMETERS
13Ø  END
```

To pause, and then erase each square after it is drawn, add these lines:

```
114  FOR PAUSE = 1 TO 2ØØ : NEXT PAUSE
116  COLR = BLACK : REM  CHANGE COLOR
118  CALL DRAW : REM  RE-DRAW SAME SHAPE, IN NEW COLOR
```

PART E: DRAWING SHAPES FROM A PREPARED SHAPE TABLE

Before either of the two shape-drawing subroutines DRAW or DRAW1 can be used, a "Shape Table" must be defined and stored in memory (see PART E: CREATING A SHAPE TABLE), the Shape Table's starting address must be specified in hexadecimal locations 328 and 329 (8Ø8 and 8Ø9, in decimal), and the High-Resolution subroutines themselves must have been initialized by a CALL INIT.

ASSIGNING PARAMETER VALUES

The DRAW subroutine is used to display any of the shapes defined in the current Shape Table. The origin or 'beginning point' for DRAWing the shape is specified by the values assigned to XØ and YØ, and the rest of the shape continues from that point. The color of the shape to be DRAWn is specified by the value of COLR.

The shape number (the Shape Table's particular shape definition that you wish to have DRAWn) is specified by the value of SHAPE. For example,

```
SHAPE = 3
```

specifies that the next shape-drawing command will use the third shape definition in the Shape Table. SHAPE may be assigned any value (from 1 through 255) that corresponds to one of the shape definitions in the current Shape Table. An attempt to DRAW a shape that does not exist (by executing a shape-drawing command after setting SHAPE = 4, when there are only two shape definitions in your Shape Table, for instance) will result in a *** RANGE ERR message being displayed, and the program will halt.

The relative size of the shape to be DRAWn is specified by the value assigned to SCALE. For example,

```
SCALE = 4
```

specifies that the next shape DRAWn will be four times the size that is described by the appropriate shape definition. That is, each "plotting vector" (either a plot and a move, or just a move) will be repeated four times. SCALE may be assigned any value from Ø through 255, but SCALE = Ø is interpreted as SCALE = 256, the largest size for a given shape definition.

You can also specify the orientation or angle of the shape to be DRAWn, by assigning the proper value to ROT. For example,

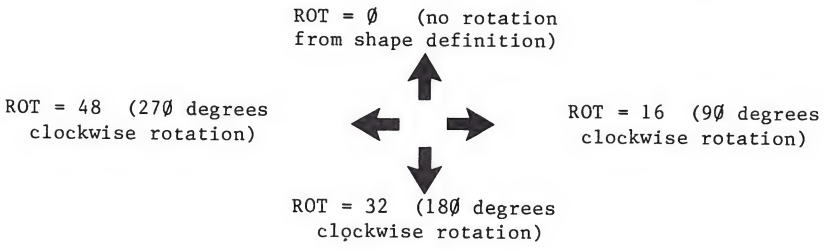
```
ROT = Ø
```

will cause the next shape to be DRAWn oriented just as it was defined, while

```
ROT = 16
```

will cause the next shape to be DRAWn rotated 9Ø degrees clockwise. The value assigned to ROT must be within the range Ø to 255 (although ROT=64, specifying a rotation of 36Ø degrees clockwise, is the equivalent of ROT=Ø). For SCALE=1, only four of the 63 different rotations are recognized (Ø,16,32,48); for SCALE=2, eight different rotations are recognized; etc. ROT values specifying unrecognized rotations will usually cause the shape to be DRAWn with the next smaller recognized rotation.

ORIENTATIONS OF SHAPE DEFINITION



DRAWING SHAPES

The following example program DRAWs shape definition number three, in white, at a 135 degree clockwise rotation. Its starting point, or origin, is at (14Ø,8Ø).

```
Ø  XØ = YØ = COLR = SHAPE = ROT = SCALE : REM  SET PARAMETERS
5  INIT = -12288 : DRAW = -11465 : REM  DEFINE SUBROUTINES
1Ø  WHITE = 127 : REM  DEFINE COLOR
2Ø  CALL INIT : REM  INITIALIZE HIGH-RESOLUTION SUBROUTINES
3Ø  XØ = 14Ø : YØ = 8Ø : COLR = WHITE : REM  ASSIGN PARAMETER VALUES
4Ø  SHAPE = 3 : ROT = 24 : SCALE = 2
5Ø  CALL DRAW : REM  DRAW SHAPE 3, DOUBLE SIZE, TURNED 135 DEGREES
6Ø  END
```

LINKING SHAPES

DRAW1 is identical to DRAW, except that the last point previously DRAWn, PLOTted or POSNed determines the color and the starting point for the new shape. XØ, YØ, and COLR, need not be specified, as they will have no effect on DRAW1. However, some point must have been plotted before CALLing DRAW1, or this CALL will have no effect.

The following example program draws "squiggles" by DRAWing a small shape whose orientation is given by game control #Ø, then linking a new shape to the old one, each time the game control gives a new orientation. To clear the screen of "squiggles," press the game-control button.

```
1Ø  XØ = YØ = COLR = SHAPE = ROT = SCALE : REM  SET PARAMETERS
2Ø  INIT = -12288 : DRAW = -11465 : DRAW1 = -11462
22  CLEAR = -12274 : WHITE = 127 : REM  NAME SUBROUTINES AND COLOR
3Ø  FULLSCREEN = -163Ø2 : BUTN = -16287 : REM  NAME LOCATIONS
4Ø  CALL INIT : REM  INITIALIZE HIGH-RESOLUTION SUBROUTINES
5Ø  POKE FULLSCREEN, Ø : REM  SET FULL-SCREEN GRAPHICS
6Ø  COLR = WHITE : SHAPE = 1 : SCALE = 5
7Ø  XØ = 14Ø : YØ = 8Ø : REM  ASSIGN PARAMETER VALUES
8Ø  CALL CLEAR : ROT = PDL(Ø) : CALL DRAW : REM  DRAW FIRST SHAPE
9Ø  IF PEEK(BUTN) > 127 THEN GOTO 8Ø : REM  PRESS BUTTON TO CLEAR SCREEN
1ØØ  R = PDL(Ø) : IF (R < ROT+2) AND (R > ROT-2) THEN GOTO 9Ø :
     REM  WAIT FOR CHANGE IN GAME CONTROL
11Ø  ROT = R : CALL DRAW1 : REM  ADD TO "SQUIGGLE"
12Ø  GOTO 9Ø : REM  LOOK FOR ANOTHER CHANGE
```

After DRAWing a shape, you may wish to draw a LINE from the last plotted point of the shape to another fixed point on the screen. To do this, once the shape is DRAWn, you must first use

```
CALL FIND
```

prior to CALLing LINE. The FIND subroutine determines the X and Y coordinates of the final point in the shape that was DRAWn, and uses it as the beginning point for the subsequent CALL LINE.

The following example DRAWs a white shape, and then draws a violet LINE from the final plot position of the shape to the point (1Ø, 25).

```
Ø  XØ = YØ = COLR = SHAPE = ROT = SCALE : REM  SET PARAMETERS
5  INIT = -12288 : LINE = -115ØØ : DRAW = -114Ø2 : FIND = -1178Ø
1Ø  VIOLET = 85 : WHITE = 127 : REM  DEFINE SUBROUTINES AND COLORS
2Ø  XØ = 14Ø : YØ = 8Ø : COLR = WHITE : REM  ASSIGN PARAMETER VALUES
3Ø  SHAPE = 3 : ROT = Ø : SCALE = 2
4Ø  CALL DRAW : REM  DRAW SHAPE WITH ABOVE PARAMETERS
5Ø  CALL FIND : REM  FIND COORDINATES OF LAST SHAPE POINT
6Ø  XØ = 1Ø : YØ = 25 : COLR = VIOLET : REM  NEW PARAMETER VALUES, FOR LINE
7Ø  CALL LINE : REM  DRAW LINE WITH ABOVE PARAMETERS
8Ø  END
```

COLLISIONS

Any time two or more shapes intersect or overlap, the new shape has points in common with the previous shapes. These common points are called points of "collision."

The DRAW and DRAW1 subroutines return a "collision count" in the hexadecimal memory location $32A (81Ø, in decimal). The collision count will be constant for a fixed shape, rotation, scale, and background, provided that no collisions with other shapes are detected. The difference between the "standard" collision value and the value encountered while DRAWing a shape is a true collision counter. For example, the collision counter is useful for determining whether or not two constantly moving shapes ever touch each other.

```
11Ø  CALL DRAW : REM DRAW THE SHAPE
12Ø  COUNT = PEEK(81Ø) : REM FIND THE COLLISION COUNT
```

PART F: TECHNICAL INFORMATION

LOCATIONS OF THE HIGH-RESOLUTION PARAMETERS

When the high-resolution parameters are entered (line Ø, say), they are stored -- with space for their values -- in the BASIC variable table, just above LOMEM (the LOwest MEMory location used for BASIC variable storage). These parameters appear in the variable table in the exact order of their first mention in the BASIC program. That order must be as shown below, because the High-Resolution subroutines look for the parameter values by location only. Each parameter value is two bytes in length. The low-order byte is stored in the lesser of the two locations assigned.

VARIABLE-TABLE PARAMETER LOCATIONS

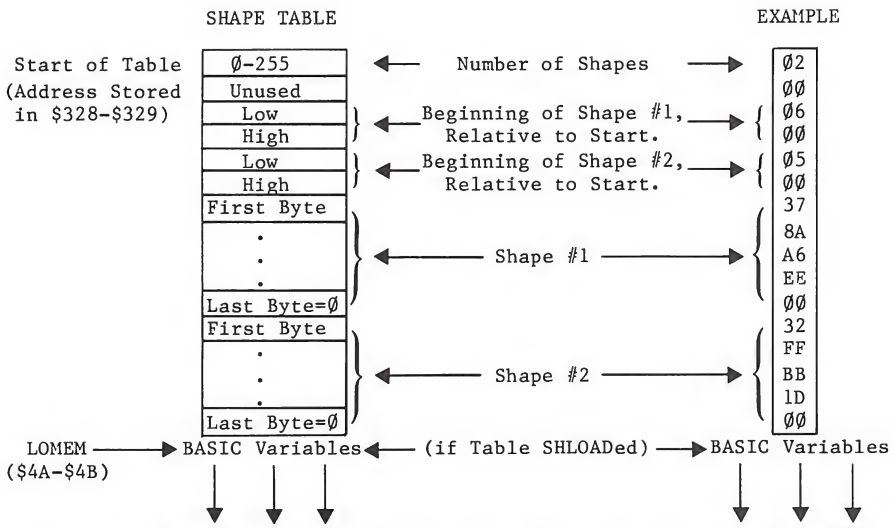
Parameter	Locations beyond LOMEM
XØ	$Ø5, $Ø6
YØ	$ØC, $ØD
COLR	$15, $16
SHAPE	$1F, $2Ø
ROT	$27, $28
SCALE	$31, $32

VARIABLES USED WITHIN THE HIGH-RESOLUTION SUBROUTINES

Variable Name	Hexadecimal Location	Description
SHAPEL, SHAPEH	1A, 1B	On-the-fly shape pointer.
HCOLOR1	1C	On-the-fly color byte.
COUNTH	1D	High-order byte of step count for LINE.
HBASL, HBASH	26, 27	On-the-fly BASE ADDRESS
HMASK	3Ø	On-the-fly BIT MASK
QDRNT	53	2 LSB's are rotation quadrant for DRAW.
XOL, XOH	32Ø, 321	Most recent X-coordinate. Used for initial endpoint of LINE. Updated by PLOT, POSN, LINE and FIND, not DRAW.
YO	322	Most recent Y-coordinate (see XOL, XOH).
BXSAV	323	Saves 65Ø2 X-register during high-resolution CALLs from BASIC.
HCOLOR	324	Color specification for PLOT, POSN.
HNDX	325	On-the-fly byte index from BASE ADDRESS.
HPAG	326	Memory page for plotting graphics. Normally $2Ø for plotting in Page 1 of high-resolution display memory ($2ØØØ-$3FFF).
SCALE	327	On-the-fly scale factor for DRAW.
SHAPXL, SHAPXH	328, 329	Start of Shape Table pointer.
COLLSN	32A	Collision count from DRAW, DRAW1.

SHAPE TABLE INFORMATION

Shape Tape	Description
Record #1	A two-byte-long record that contains the length of record #2, Low-order first.
Record Gap	Minumum of .7 seconds in length.
Record #2	The Shape Table (see below).

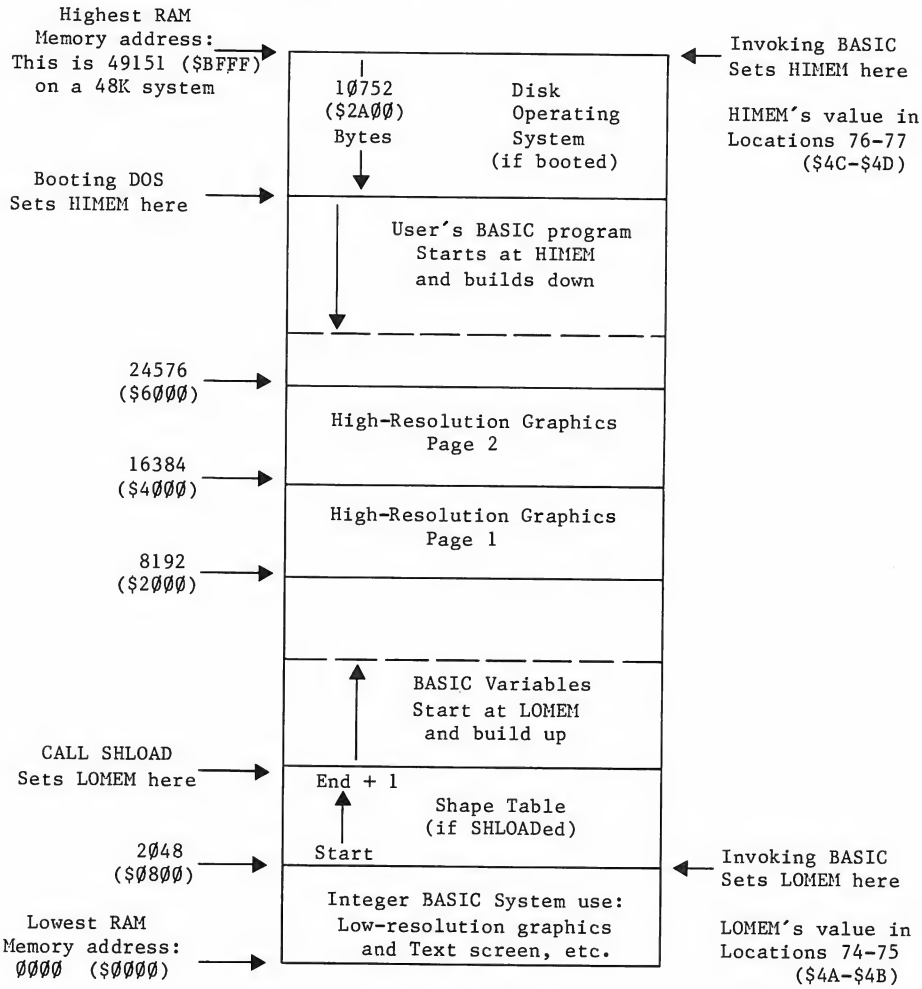


The address of the Shape Table's Start should be stored in locations $328 and $329. If the SHLOAD subroutine is used to load the table, Start will be set to LOMEM (normally this is at $Ø8ØØ) and then LOMEM will be moved to one byte after the end of the Shape Table, automatically.

If you wish to load a Shape Table named MYSHAPES2 from disk, beginning at decimal location 2Ø48 (Ø8ØØ hex), and ending at decimal location 2Ø48 plus decimal 15 bytes (as in the example above), you may wish to begin your BASIC program as follows:

```
Ø  D$ = "" : REM  QUOTES CONTAIN CTRL D (D$ WILL BE ERASED BY SHAPE TABLE)
1  PRINT D$; "BLOAD MYSHAPES2 , A 2Ø48" : REM  LOADS SHAPE TABLE
2  POKE 8Ø8, 2Ø48 MOD 256 : POKE 8Ø9, 2Ø48 / 256 : REM  SETS TABLE START
3  POKE 74, (2Ø48 + 15 + 1) MOD 256 : POKE 75, (2Ø48 + 15 + 1) / 256
4  POKE 2Ø4, PEEK(74) : POKE 2Ø5, PEEK(75) : REM  SETS LOMEM TO TABLE END+1
5  XØ = YØ = COLR = SHAPE = ROT = SCALE : REM  SETS PARAMETERS
```

APPLE II MEMORY MAP FOR USING HIGH-RESOLUTION GRAPHICS WITH INTEGER BASIC



Unfortunately, there is no convention for mapping memory. This map shows the highest (largest) address at the top, lowest (smallest) address at the bottom. The maps of Shape Tables that appear on other pages show the Starting address (lowest and smallest) at the top, the Ending address (highest and largest) at the bottom.

PART G: COMMENTS

1. Using memory Page 1 for high-resolution graphics erases everything in memory from location 8192 ($2ØØØ hex) to location 16383 ($3FFF). If the top of your system's memory is in this range (as it will be, if you have a 16K system), Integer BASIC will normally put your BASIC program exactly where it will be erased by INIT. You must protect your program by setting HIMEM below memory Page 1, after invoking BASIC (reset ctrl B return) and before RUNning your program: use this immediate-execution command:

```
HIMEM: 8192    return
```

2. Using memory Page 2 for high-resolution graphics erases memory from location 16384 ($4ØØØ) to location 24575 ($5FFF). If yours is a 24K system, this will erase your BASIC program unless you do one of the following:

a) never use Page 2 for graphics; or
b) change HIMEM to 8192, as described above.

3. The picture is further confused if you are also using an APPLE disk with your system. The Disk Operating System (DOS), when booted, occupies the highest 1Ø.5K ($2AØØ) bytes of memory. HIMEM is moved to just below the DOS. Therefore, if your system contains less than 32K of memory, the DOS will occupy memory Page 1 and Page 2. In that case, you cannot use the High-Resolution graphics with the DOS intact. An attempt to do so will erase all or part of the DOS. A 32K system can use only Page 1 for graphics without destroying the DOS, but HIMEM must be moved to location 8192 as described above. 48K systems can usually use the DOS and both high-resolution memory pages without problems.

4. If you loaded your Shape Table starting at LOMEM in location 2Ø48 ($Ø8ØØ), from disk or from tape without using SHLOAD, Integer BASIC will erase the Shape Table when it stores the program variables. To protect your Shape Table, you must move LOMEM to one byte beyond the last byte of the Shape Table, after invoking BASIC and before using <u>any</u> variables. SHLOAD does this automatically, but you can use this immediate-execution command:

```
LOMEM: 2Ø48 + tablelength + 1
```

where tablelength must be a number, <u>not</u> a variable name. Some programmers load their Shape Tables beginning in location 3Ø48 ($ØBE8). That leaves a safe margin of 1ØØØ bytes for variables below the Shape Table, and at least 5ØØØ bytes (if HIMEM:8192) above the table for their BASIC program.

5. CALLing an undefined or accidentally misspelled variable name is usually a CALL to location zero (the default value of any undefined variable). This CALL may cause unpredictable and unwelcome results, depending on the contents of location zero. However, after you execute this BASIC command:

```
POKE Ø, 96
```

an accidental CALL to location zero will cause a simple jump back to your BASIC program, with no damage.

APPENDIX I
SOURCE ASSEMBLY LISTINGS

```
                        1 ****************************
                        2 *                          *
                        3 * APPLE-II HI-RESOLUTION  *
                        4 *  GRAPHICS SUBROUTINES    *
                        5 *                          *
                        6 *    BY WOZ   9/13/77      *
                        7 *                          *
                        8 *  ALL RIGHTS RESERVED     *
                        9 *                          *
                       10 ****************************

                       12 *  HI-RES EQUATES
                       13 SHAPEL EQU   $1A POINTER TO
                       14 SHAPEH EQU   $1B SHAPE LIST
                       15 HCOLOR1 EQU   $1C RUNNING COLOR MASK
                       16 COUNTH EQU   $1D
                       17 HBASL  EQU   $26 BASE ADR FOR CURRENT
                       18 HBASH  EQU   $27  HI-RES PLOT LINE. A
                       19 HMASK  EQU   $30
                       20 A1L    EQU   $3C MONITOR A1.
                       21 A1H    EQU   $3D
                       22 A2L    EQU   $3E MONITOR A2.
                       23 A2H    EQU   $3F
                       24 LOMEML EQU   $4A BASIC 'START OF VARS'.
                       25 LOMEMH EQU   $4B
                       26 DXL    EQU   $50 DELTA-X FOR HLIN, SHAPE.
                       27 DXH    EQU   $51
                       28 SHAPEX EQU   $51 SHAPE TEMP.
                       29 DY     EQU   $52 DELTA-Y FOR HLIN, SHAPE.
                       30 QDRNT  EQU   $53 ROT QUADRANT (SHAPE).
                       31 EL     EQU   $54 ERROR FOR HLIN.
                       32 EH     EQU   $55
                       33 PPL    EQU   $CA BASIC START OF PROG PTR.
                       34 PPH    EQU   $CB
                       35 PVL    EQU   $CC BASIC END OF VARS PTR.
                       36 PVH    EQU   $CD
                       37 ACL    EQU   $CE BASIC ACC.
                       38 ACH    EQU   $CF
                       39 XOL    EQU   $320 PRIOR X-COORD SAVE
                       40 XOH    EQU   $321 AFTER HLIN OR HPLOT.
                       41 YO     EQU   $322 HLIN, HPLOT Y-COORD SAVE.
                       42 BXSAV  EQU   $323 X-REG SAVE FOR BASIC.
                       43 HCOLOR EQU   $324 COLOR FOR HPLOT, HPOSN
                       44 HNDX   EQU   $325 HORIZ OFFSET SAVE.
                       45 HPAG   EQU   $326 HI-RES PAGE ($20 NORMAL)
                       46 SCALE  EQU   $327 SCALE FOR SHAPE, MOVE.
                       47 SHAPXL EQU   $328 START OF
                       48 SHAPXH EQU   $329   SHAPE TABLE.
                       49 COLLSN EQU   $32A COLLISION COUNT.
                       50 HIRES  EQU   $C057 SWITCH TO HI-RES VIDEO
                       51 MIXSET EQU   $C053 SELECT TEXT/GRAPHICS MIX
                       52 TXTCLR EQU   $C050 SELECT GRAPHICS MODE.
                       53 MEMFUL EQU   $E36B BASIC MEM FULL ERROR.
                       54 RNGERR EQU   $E668 BASIC RANGE ERROR.
                       55 ACADR  EQU   $F11E 2-BYTE TAPE READ SETUP.
                       56 RD2BIT EQU   $FCFA TWO-EDGE TAPE SENSE.
                       57 READ   EQU   $FEFD TAPE READ (A1.A2).
                       58 READX1 EQU   $FF02 READ WITHOUT HEADER.

                       60 *  HIGH RESOLUTION GRAPHICS INITS
                       61 *
                       62 * ROM VERSION $D000 TO $D3FF
                       63 *
                       64         ORG   $D000
                       65         OBJ   $A000
D000 A9 20             66 SETHRL  LDA   #$20 INIT FOR $2000-3FFF
D002 8D 26 03          67         STA   HPAG HI-RES SCREEN MEMORY.
```

```
D005 AD 57 C0     68          LDA   HIRES SET HIRES DISPLAY MODE
D008 AD 53 C0     69          LDA   MIXSET WITH TEXT AT BOTTOM.
D00B AD 50 C0     70          LDA   TXTCLR SET GRAPHICS DISPLAY MODE
D00E A9 00        71 HCLR     LDA   #$0
D010 85 1C        72 BKGNDO   STA   HCOLOR1 SET FOR BLACK BKGND.
D012 AD 26 03     73 BKGND    LDA   HPAG
D015 85 1B        74          STA   SHAPEH INIT HI-RES SCREEN MEM
D017 A0 00        75          LDY   #$0 FOR CURRENT PAGE, NORMALLY
D019 84 1A        76          STY   SHAPEL $2000-3FFF OR $4000-5FFF
D01B A5 1C        77 BKGND1   LDA   HCOLOR1
D01D 91 1A        78          STA   (SHAPEL),Y
D01F 20 A2 D0     79          JSR   CSHFT2 (SHAPEL,H) WILL SPECIFY
D022 C8           80          INY   32 SEPARATE PAGES.
D023 D0 F6        81          BNE   BKGND1 THROUGHOUT THE INIT.
D025 E6 1B        82          INC   SHAPEH
D027 A5 1B        83          LDA   SHAPEH
D029 29 1F        84          AND   #$1F TEST FOR DONE.
D02B D0 EE        85          BNE   BKGND1
D02D 60           86          RTS

                  88 *  HI-RES GRAPHICS POSITION AND PLOT SUBRS
D02E 8D 22 03     89 HPOSN    STA   YO ENTER WITH Y IN A-REG,
D031 8E 20 03     90          STX   XOL XL IN X-REG,
D034 8C 21 03     91          STY   XOH AND XH IN Y-REG.
D037 48           92          PHA
D038 29 C0        93          AND   #$C0
D03A 85 26        94          STA   HBASL FOR Y-COORD = 00ABCDEF.
D03C 4A           95          LSR   ;CALCULATES BASE ADDRESS
D03D 4A           96          LSR   ;IN HBASL, HBASH FOR
D03E 05 26        97          ORA   HBASL     ACCESSING SCREEN MEM
D040 85 26        98          STA   HBASL     VIA (HBASL),Y ADDRESSING MODE
D042 68           99          PLA
D043 85 27       100          STA   HBASH
D045 0A          101          ASL   ;CALCULATES
D046 0A          102          ASL   ;HBASH = PPPFGHCD,
D047 0A          103          ASL   ;HBASL = EABAB000
D048 26 27       104          ROL   HBASH
D04A 0A          105          ASL   ;WHERE PPP=001 FOR $2000-3FFF
D04B 26 27       106          ROL   HBASH SCREEN MEM RANGE AND
D04D 0A          107          ASL   ; PPP=010 FOR $4000-7FFF
D04E 66 26       108          ROR   HBASL (GIVEN Y-COORD=ABCDEFGH)
D050 A5 27       109          LDA   HBASH
D052 29 1F       110          AND   #$1F
D054 0D 26 03    111          ORA   HPAG
D057 85 27       112          STA   HBASH
D059 8A          113          TXA   DIVIDE XO BY 7 FOR
D05A C0 00       114          CPY   #$0 INDEX FROM BASE ADR
D05C F0 05       115          BEQ   HPOSN2 (QUOTIENT) AND BIT
D05E A0 23       116          LDY   #$23 WITHIN SCREEN MEM BYTE
D060 69 04       117          ADC   #$4 (MASK SPEC'D BY REMAINDER)
D062 C8          118 HPOSN1  INY
D063 E9 07       119 HPOSN2  SBC   #$7 SUBTRACT OUT SEVENS.
D065 B0 FB       120          BCS   HPOSN1
D067 8C 25 03    121          STY   HNDX WORKS FOR XO FROM
D06A AA          122          TAX   0 TO 279, LOW-ORDER
D06B BD EA D0    123          LDA   MSKTBL-249,X BYTE IN X-REG,
D06E 85 30       124          STA   HMASK HIGH IN Y-REG ON ENTRY
D070 98          125          TYA
D071 4A          126          LSR   ; IF ON ODD BYTE (CARRY SET)
D072 AD 24 03    127          LDA   HCOLOR THEN ROTATE HCOLOR ONE
D075 85 1C       128 HPOSN3  STA   HCOLOR1 BIT FOR 180 DEGREE SHIFT
D077 B0 29       129          BCS   CSHFT2 PRIOR TO COPYING TO HCOLOR1.
D079 60          130          RTS
D07A 20 2E D0    131 HPLOT   JSR   HPOSN
D07D A5 1C       132 HPLOT1  LDA   HCOLOR1 CALC BIT POSN IN HBASL,H
D07F 51 26       133          EOR   (HBASL),Y HNDX, AND HMASK FROM
D081 25 30       134          AND   HMASK Y-COORD IN A-REG,
D083 51 26       135          EOR   (HBASL),Y X-COORD IN X,Y-REGS.
D085 91 26       136          STA   (HBASL),Y FOR ANY 'L' BITS OF HMASK
D087 60          137          RTS   SUBSTITUTE CORRESPONDING
                 138 *                    BIT OF HCOLOR1.
```

```
                    140 *  HI-RES GRAPHICS L,R,U,D SUBRS
D038 10 24          141 LFTRT  BPL   RIGHT USE SIGN FOR LFT/RT SELECT
D03A A5 30          142 LEFT   LDA   HMASK
D03C 4A             143        LSR   ; SHIFT LOW-ORDER
D03D B0 05          144        BCS   LEFT1 7 BITS OF HMASK
D03F 49 C0          145        EOR   #$C0 ONE BIT TO LSB.
D071 85 30          146 LR1    STA   HMASK
D073 60             147        RTS
D074 88             148 LEFT1  DEY   DECR HORIZ INDEX.
D075 10 02          149        BPL   LEFT2
D077 A0 27          150        LDY   #$27 WRAP AROUND SCREEN.
D079 A9 C0          151 LEFT2  LDA   #$C0 NEW HMASK, RIGHTMOST
D07B 85 30          152 NEWNDX STA   HMASK DOT OF BYTE.
D07D BC 25 03       153        STY   HNDX UPDATE HORIZ INDEX.
D0A0 A5 1C          154 CSHIFT LDA   HCOLOR1
D0A2 0A             155 CSHFT2 ASL   ; ROTATE LOW-ORDER
D0A3 C9 C0          156        CMP   #$C0 7 BITS OF HCOLOR1
D0A5 10 06          157        BPL   RTS1 ONE BIT POSN.
D0A7 A5 1C          158        LDA   HCOLOR1
D0A9 49 7F          159        EOR   #$7F ZXYXYXYX -> ZYXYXYXY
D0AB 85 1C          160        STA   HCOLOR1
D0AD 60             161 RTS1   RTS
D0AE A5 30          162 RIGHT  LDA   HMASK
D0B0 0A             163        ASL   ; SHIFT LOW-ORDER
D0B1 49 80          164        EOR   #$80 7 BITS OF HMASK
D0B3 30 DC          165        BMI   LR1 ONE BIT TO MSB.
D0B5 A9 81          166        LDA   #$81
D0B7 C8             167        INY   NEXT BYTE.
D0B8 C0 28          168        CPY   #$28
D0BA 90 DF          169        BCC   NEWNDX
D0BC A0 00          170        LDY   #$0 WRAP AROUND SCREEN IF >279
D0BE B0 DB          171        BCS   NEWNDX ALWAYS TAKEN.

                    173 *  L,R,U,D, SUBROUTINES.
D0C0 18             174 LRUDX1 CLC   NO 90 DEG ROT (X-OR).
D0C1 A5 51          175 LRUDX2 LDA   SHAPEX
D0C3 29 04          176        AND   #$4 IF B2=0 THEN NO PLOT.
D0C5 F0 27          177        BEQ   LRUD4
D0C7 A9 7F          178        LDA   #$7F FOR EX-OR INTO SCREEN MEM
D0C9 25 30          179        AND   HMASK
D0CB 31 26          180        AND   (HBASL),Y SCREEN BIT SET?
D0CD D0 1B          181        BNE   LRUD3
D0CF EE 2A 03       182        INC   COLLSN
D0D2 A9 7F          183        LDA   #$7F
D0D4 25 30          184        AND   HMASK
D0D6 10 12          185        BPL   LRUD3 ALWAYS TAKEN.
D0D8 18             186 LRUD1  CLC   NO 90 DEG ROT.
D0D9 A5 51          187 LRUD2  LDA   SHAPEX
D0DB 29 04          188        AND   #$4 IF B2=0 THEN NO PLOT.
D0DD F0 0F          189        BEQ   LRUD4
D0DF B1 26          190        LDA   (HBASL),Y
D0E1 45 1C          191        EOR   HCOLOR1 SET HI-RES SCREEN BIT
D0E3 25 30          192        AND   HMASK TO CORRESPONDING HCOLOR1
D0E5 D0 03          193        BNE   LRUD3 IF BIT OF SCREEN CHANGES
D0E7 EE 2A 03       194        INC   COLLSN THEN INCR COLLSN DETECT
D0EA 51 26          195 LRUD3  EOR   (HBASL),Y
D0EC 91 26          196        STA   (HBASL),Y
D0EE A5 51          197 LRUD4  LDA   SHAPEX ADD QDRNT TO
D0F0 65 53          198        ADC   QDRNT SPECIFIED VECTOR
D0F2 29 03          199        AND   #$3 AND MOVE LFT, RT,
                    200 EQ3    EQU   *-1 UP, OR DWN BASED
D0F4 C9 02          201        CMP   #$2 ON SIGN AND CARRY.
D0F6 6A             202        ROR
D0F7 B0 8F          203 LRUD   BCS   LFTRT
D0F9 30 30          204 UPDWN  BMI   DOWN4 SIGN FOR UP/DWN SELECT
D0FB 18             205 UP     CLC
D0FC A5 27          206        LDA   HBASH CALC BASE ADDRESS
D0FE 2C EA D1       207        BIT   EQ1C (ADR OF LEFTMOST BYTE)
D101 D0 22          208        BNE   UP4 FOR NEXT LINE UP
D103 06 26          209        ASL   HBASL IN (HBASL, HBASH)
```

```
D105 B0 1A      210         BCS   UP2 WITH 192-LINE WRAPAROUND
D107 2C F3 D0   211         BIT   EQ3
D10A F0 05      212         BEQ   UP1
D10C 69 1F      213         ADC   #$1F **** BIT MAP ****
D10E 38         214         SEC
D10F B0 12      215         BCS   UP3 FOR ROW = ABCDEFGH,
D111 69 23      216 UP1     ADC   #$23
D113 48         217         PHA
D114 A5 26      218         LDA   HBASL HBASL = EABABOOO
D116 69 B0      219         ADC   #$B0 HBASH = PPPFGHCD
D118 B0 02      220         BCS   UP5
D11A 69 F0      221         ADC   #$F0 WHERE PPP=001 FOR PRIMARY
D11C 85 26      222 UP5     STA   HBASL HI-RES PAGE ($2000-$3FFF)
D11E 68         223         PLA
D11F B0 02      224         BCS   UP3
D121 69 1F      225 UP2     ADC   #$1F
D123 66 26      226 UP3     ROR   HBASL
D125 69 FC      227 UP4     ADC   #$FC
D127 85 27      228 UPDWN1  STA   HBASH
D129 60         229         RTS
D12A 18         230 DOWN    CLC
D12B A5 27      231 DOWN4   LDA   HBASH
D12D 69 04      232         ADC   #$4 CALC BASE ADR FOR NEXT LINE
                233 EQ4     EQU   *-1 DOWN TO (HBASL,HBASH)
D12F 2C EA D1   234         BIT   EQ1C
D132 D0 F3      235         BNE   UPDWN1

D134 06 26      236         ASL   HBASL WITH 192-LINE WRAPAROUND
D136 90 19      237         BCC   DOWN1
D138 69 E0      238         ADC   #$E0
D13A 18         239         CLC
D13B 2C 2E D1   240         BIT   EQ4
D13E F0 13      241         BEQ   DOWN2
D140 A5 26      242         LDA   HBASL
D142 69 50      243         ADC   #$50
D144 49 F0      244         EOR   #$F0
D146 F0 02      245         BEQ   DOWN3
D148 49 F0      246         EOR   #$F0
D14A 85 26      247 DOWN3   STA   HBASL
D14C AD 26 03   248         LDA   HPAG
D14F 90 02      249         BCC   DOWN2
D151 69 E0      250 DOWN1   ADC   #$E0
D153 66 26      251 DOWN2   ROR   HBASL
D155 90 D0      252         BCC   UPDWN1

                254 *  HI-RES GRAPHICS LINE DRAW SUBRS
D157 48         255 HLINRL  PHA
D158 A9 00      256         LDA   #$0 SET (XOL,XOH) AND
D15A 8D 20 03   257         STA   XOL YO TO ZERO FOR
D15D 8D 21 03   258         STA   XOH REL LINE DRAW
D160 8D 22 03   259         STA   YO (DX, DY).
D163 68         260         PLA
D164 48         261 HLIN    PHA   ON ENTRY
D165 38         262         SEC   XL: A-REG
D166 ED 20 03   263         SBC   XOL XH; X-REG
D169 48         264         PHA   Y: Y-REG
D16A 8A         265         TXA
D16B ED 21 03   266         SBC   XOH
D16E 85 53      267         STA   QDRNT CALC ABS(X-XO)
D170 B0 0A      268         BCS   HLIN2 IN (DXL,DXH)
```

```
D172 68          269          PLA
D173 49 FF       270          EOR   #$FF X DIR TO SIGN BIT
D175 69 01       271          ADC   #$1 OF QDRNT.
D177 48          272          PHA   0=RIGHT (DX POS)
D178 A9 00       273          LDA   #$0 1=LEFT (DX NEG)
D17A E5 53       274          SBC   QDRNT
D17C 85 51       275 HLIN2    STA   DXH
D17E 85 55       276          STA   EH INIT (EL,EH) TO
D180 68          277          PLA   ABS(X-XO)
D181 85 50       278          STA   DXL
D183 85 54       279          STA   EL
D185 68          280          PLA
D186 8D 20 03    281          STA   XOL
D189 8E 21 03    282          STX   XOH
D18C 98          283          TYA
D18D 18          284          CLC
D18E ED 22 03    285          SBC   YO CALC -ABS(Y-O)-1
D191 90 04       286          BCC   HLIN3 IN DY.
D193 49 FF       287          EOR   #$FF
D195 69 FE       288          ADC   #$FE
D197 85 52       289 HLIN3    STA   DY ROTATE Y DIR INTO
D199 8C 22 03    290          STY   YO QDRNT SIGN BIT
D19C 66 53       291          ROR   QDRNT (O=UP, 1=DOWN)
D19E 38          292          SEC
D19F E5 50       293          SBC   DXL INIT (COUNTL, COUNTH).
D1A1 AA          294          TAX   TO -(DELTX+DELTY+1)
D1A2 A9 FF       295          LDA   #$FF
D1A4 E5 51       296          SBC   DXH
D1A6 85 1D       297          STA   COUNTH
D1A8 AC 25 03    298          LDY   HNDX HORIZ INDEX
D1AB B0 05       299          BCS   MOVEX2 ALWAYS TAKEN.
D1AD 0A          300 MOVEX    ASL   ; MOVE IN X-DIR. USE
D1AE 20 88 D0    301          JSR   LFTRT QDRNT B6 FOR LFT/RT SELECT
D1B1 38          302          SEC
D1B2 A5 54       303 MOVEX2   LDA   EL ASSUME CARRY SET.
D1B4 65 52       304          ADC   DY (EL,EH)-DELTY TO (EL,EH)
D1B6 85 54       305          STA   EL NOTE: DY IS (-DELTY)-1
D1B8 A5 55       306          LDA   EH CARRY CLR IF (EL,EH)
D1BA E9 00       307          SBC   #$0 GOES NEG.
D1BC 85 55       308 HCOUNT   STA   EH
D1BE B1 26       309          LDA   (HBASL),Y SCREEN BYTE.
D1C0 45 1C       310          EOR   HCOLOR1 PLOT DOT OF HCOLOR1.
D1C2 25 30       311          AND   HMASK CURRENT BIT MASK.
D1C4 51 26       312          EOR   (HBASL),Y
D1C6 91 26       313          STA   (HBASL),Y
D1C8 E8          314          INX   DONE (DELTX+DELTY)
D1C9 D0 04       315          BNE   HLIN4 DOTS?
D1CB E6 1D       316          INC   COUNTH
D1CD F0 6B       317          BEQ   RTS2 YES, RETURN.
D1CF A5 53       318 HLIN4    LDA   QDRNT FOR DIRECTION TEST
D1D1 B0 DA       319          BCS   MOVEX IF CAR SET, (EL, EH) POS
D1D3 20 F9 D0    320          JSR   UPDWN IF CLR, NEG, MOVE YDIR
D1D6 18          321          CLC
D1D7 A5 54       322          LDA   EL (EL,EH)+DELTX
D1D9 65 50       323          ADC   DXL TO (EL,EH).
D1DB 85 54       324          STA   EL
D1DD A5 55       325          LDA   EH CAR SET IF (EL,EH) GOES POS
D1DF 65 51       326          ADC   DXH
D1E1 50 D9       327          BVC   HCOUNT ALWAYS TAKEN.
D1E3 81          328 MSKTBL   HEX   81 LEFTMOST BIT OF BYTE.
D1E4 82 84 88    329          HEX   82,84,88
D1E7 90 A0       330          HEX   90,A0
D1E9 C0          331          HEX   C0 RIGHTMOST BIT OF BYTE.
D1EA 1C          332 EQ1C     HEX   1C
D1EB FF FE FA    333 COS      HEX   FF,FE,FA,F4,EC,E1,D4,C5,B4
D1F4 A1 8D 78    334          HEX   A1,8D,78,61,49,31,18,FF
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                        336 *  HI-RES GRAPHICS COORDINATE RESTORE SUBR
D1FC A5 26              337 HFIND  LDA   HBASL
D1FE 0A                 338        ASL   ; CONVERTS BASE ADR
D1FF A5 27              339        LDA   HBASH TO Y-COORD.
D201 29 03              340        AND   #$3
D203 2A                 341        ROL   ; FOR HBASL = EABABOOO
D204 05 26              342        ORA   HBASL HBASH = PPPFGHCD
D206 0A                 343        ASL
D207 0A                 344        ASL   ; GENERATE
D208 0A                 345        ASL   ; Y-COORD = ABCDEFGH
D209 8D 22 03           346        STA   YO
D20C A5 27              347        LDA   HBASH (PPP=SCREEN PAGE,
D20E 4A                 348        LSR   ; NORMALLY 001 FOR
D20F 4A                 349        LSR   ; $2000-$3FFF
D210 29 07              350        AND   #$7 HI-RES SCREEN)
D212 0D 22 03           351        ORA   YO
D215 8D 22 03           352        STA   YO CONVERTS HNDX (INDEX
D218 AD 25 03           353        LDA   HNDX FROM BASE ADR)
D21B 0A                 354        ASL   ; AND HMASK (BIT
D21C 6D 25 03           355        ADC   HNDX MASK) TO X-COORD
D21F 0A                 356        ASL   ; IN (XOL,XOH)
D220 AA                 357        TAX   (RANGE $0-$133)
D221 CA                 358        DEX
D222 A5 30              359        LDA   HMASK
D224 29 7F              360        AND   #$7F
D226 E8                 361 HFIND1 INX
D227 4A                 362        LSR
D228 D0 FC              363        BNE   HFIND1
D22A 8D 21 03           364        STA   XOH
D22D 8A                 365        TXA
D22E 18                 366        CLC   CALC HNDX*7 +
D22F 6D 25 03           367        ADC   HNDX LOG (BASE 2) HMASK.
D232 90 03              368        BCC   HFIND2
D234 EE 21 03           369        INC   XOH
D237 8D 20 03           370 HFIND2 STA   XOL
D23A 60                 371 RTS2   RTS

                        373 *  HI-RES GRAPHICS SHAPE DRAW SUBR
                        374 *
                        375 * SHAPE DRAW
                        376 * R = 0 TO 63
                        377 * SCALF FACTOR USED (1=NORMAL)
                        378 *
D23B 86 1A              379 DRAW   STX   SHAPEL. DRAW DEFINITION
D23D 84 1B              380        STY   SHAPEH POINTER.
D23F AA                 381 DRAW1  TAX
D240 4A                 382        LSR   ; ROT ($0-$3F)
D241 4A                 383        LSR
D242 4A                 384        LSR   ; QDRNT 0=UP, 1=RT,
D243 4A                 385        LSR   ; 2=DWN, 3=LFT.
D244 85 53              386        STA   QDRNT
D246 8A                 387        TXA
D247 29 0F              388        AND   #$F
D249 AA                 389        TAX
D24A BC EB D1           390        LDY   COS,X SAVE COS AND SIN
D24D 84 50              391        STY   DXL VALS IN DXL AND DY.
D24F 49 0F              392        EOR   #$F
D251 AA                 393        TAX
D252 BC EC D1           394        LDY   COS+1,X
D255 C8                 395        INY
D256 84 52              396        STY   DY
D258 AC 25 03           397 DRAW2  LDY   HNDX BYTE INDEX FROM
D25B A2 00              398        LDX   #$0 HI-RES BASE ADR.
D25D 8E 2A 03           399        STX   COLLSN CLEAR COLLISION COUNT.
D260 A1 1A              400        LDA   (SHAPEL,X) 1ST SHAPE DEF BYTE.
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D262 85 51      401 DRAW3  STA   SHAPEX
D264 A2 80      402        LDX   #$80
D266 86 54      403        STX   EL EL,EH FOR FRACTIONAL
D268 86 55      404        STX   EH L,R,U,D VECTORS.
D26A AE 27 03   405        LDX   SCALE SCALE FACTOR.
D26D A5 54      406 DRAW4  LDA   EL
D26F 38         407        SEC   IF FRAC COS OVFL
D270 65 50      408        ADC   DXL THEN MOVE IN
D272 85 54      409        STA   EL SPECIFIED VECTOR
D274 90 04      410        BCC   DRAW5 DIRECTION.
D276 20 D8 D0   411        JSR   LRUD1
D279 18         412        CLC
D27A A5 55      413 DRAW5  LDA   EH IF FRAC SIN OVFL
D27C 65 52      414        ADC   DY THEN MOVE IN
D27E 85 55      415        STA   EH SPECIFIED VECTOR
D280 90 03      416        BCC   DRAW6 DIRECTION +90 DEG.
D282 20 D9 D0   417        JSR   LRUD2
D285 CA         418 DRAW6  DEX   LOOP ON SCALE
D286 D0 E5      419        BNE   DRAW4 FACTOR.
D288 A5 51      420        LDA   SHAPEX
D28A 4A         421        LSR   ; NEXT 3-BIT VECTOR
D28B 4A         422        LSR   ; OF SHAPE DEF.
D28C 4A         423        LSR
D28D D0 D3      424        BNE   DRAW3 NOT DONE THIS BYTE.
D28F E6 1A      425        INC   SHAPEL
D291 D0 02      426        BNE   DRAW7 NEXT BYTE OF
D293 E6 1B      427        INC   SHAPEH SHAPE DEFINITION.
D295 A1 1A      428 DRAW7  LDA   (SHAPEL,X)
D297 D0 C9      429        BNE   DRAW3 DONE IF ZERO.
D299 60         430        RTS

                432 *  HI-RES GRAPHICS SHAPE EX-OR SUBR
                433 *
                434 * EX-OR SHAPE INTO SCREEN.
                435 *
                436 * ROT = 0 TO 3 (QUADRANT ONLY)
                437 * SCALE IS USED
                438 *
D29A 86 1A      439 XDRAW  STX   SHAPEL SHAPE DEFINITION
D29C 84 1B      440        STY   SHAPEH POINTER.
D29E AA         441 XDRAW1 TAX
D29F 4A         442        LSR   ; ROT ($0-$3F)
D2A0 4A         443        LSR
D2A1 4A         444        LSR   ; QDRNT 0=UP, 1=RT,
D2A2 4A         445        LSR   ; 2=DWN, 3=LFT.
D2A3 85 53      446        STA   QDRNT
D2A5 8A         447        TXA
D2A6 29 0F      448        AND   #$F
D2A8 AA         449        TAX
D2A9 BC EB D1   450        LDY   COS,X SAVE COS AND SIN
D2AC 84 50      451        STY   DXL VALS IN DXL AND DY,
D2AE 49 0F      452        EOR   #$F
D2B0 AA         453        TAX
D2B1 BC EC D1   454        LDY   COS+1,X
D2B4 C8         455        INY
D2B5 84 52      456        STY   DY
D2B7 AC 25 03   457 XDRAW2 LDY   HNDX INDEX FROM HI-RES
D2BA A2 00      458        LDX   #$0 BASE ADR.
D2BC 8E 2A 03   459        STX   COLLSN CLEAR COLLISION DETECT
D2BF A1 1A      460        LDA   (SHAPEL,X) 1ST SHAPE DEF BYTE.
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D2C1 85 51      461 XDRAW3 STA   SHAPEX
D2C3 A2 80      462        LDX   #$80
D2C5 86 54      463        STX   EL EL,EH FOR FRACTIONAL
D2C7 86 55      464        STX   EH L,R,U,D, VECTORS.
D2C9 AE 27 03   465        LDX   SCALE SCALE FACTOR.
D2CC A5 54      466 XDRAW4 LDA   EL
D2CE 38         467        SEC   IF FRAC COS OVFL
D2CF 65 50      468        ADC   DXL THEN MOVE IN
D2D1 85 54      469        STA   EL SPECIFIED VECTOR
D2D3 90 04      470        BCC   XDRAW5 DIRECTION
D2D5 20 C0 D0   471        JSR   LRUDX1
D2D8 18         472        CLC
D2D9 A5 55      473 XDRAW5 LDA   EH IF FRAC SIN OVFL
D2DB 65 52      474        ADC   DY THEN MOVE IN
D2DD 85 55      475        STA   EH SPECIFIED VECTOR
D2DF 90 03      476        BCC   XDRAW6 DIRECTION +90 DEG.
D2E1 20 D9 D0   477        JSR   LRUD2
D2E4 CA         478 XDRAW6 DEX   LOOP ON SCALE
D2E5 D0 E5      479        BNE   XDRAW4 FACTOR.
D2E7 A5 51      480        LDA   SHAPEX
D2E9 4A         481        LSR   ; NEXT 3-BIT VECTOR
D2EA 4A         482        LSR   ; OF SHAPE DEF.
D2EB 4A         483        LSR
D2EC D0 D3      484        BNE   XDRAW3
D2EE E6 1A      485        INC   SHAPEL
D2F0 D0 02      486        BNE   XDRAW7 NEXT BYTE OF
D2F2 E6 1B      487        INC   SHAPEH SHAPE DEF.
D2F4 A1 1A      488 XDRAW7 LDA   (SHAPEL,X)
D2F6 D0 C9      489        BNE   XDRAW3 DONE IF ZERO.
D2F8 60         490        RTS

                492 *  ENTRY POINTS FROM APPLE-II BASIC
D2F9 20 90 D3   493 BPOSN  JSR   PCOLR POSN CALL, COLR FROM BASIC
D2FC 8D 24 03   494        STA   HCOLOR
D2FF 20 AF D3   495        JSR   GETYO YO FROM BASIC.
D302 48         496        PHA
D303 20 9A D3   497        JSR   GETXO XO FROM BASIC.
D306 68         498        PLA
D307 20 2E D0   499        JSR   HPOSN
D30A AE 23 03   500        LDX   BXSAV
D30D 60         501        RTS
D30E 20 F9 D2   502 BPLOT  JSR   BPOSN PLOT CALL (BASIC).
D311 4C 7D D0   503        JMP   HPLOT1
D314 AD 25 03   504 BLIN1  LDA   HNDX
D317 4A         505        LSR   ; SET HCOLOR1 FROM
D318 20 90 D3   506        JSR   PCOLR BASIC VAR COLR.
D31B 20 75 D0   507        JSR   HPOSN3
D31E 20 9A D3   508 BLINE  JSR   GETXO LINE CALL, GET XO FROM BASIC
D321 8A         509        TXA
D322 48         510        PHA
D323 98         511        TYA
D324 AA         512        TAX
D325 20 AF D3   513        JSR   GETYO YO FROM BASIC
D328 A8         514        TAY
D329 68         515        PLA
D32A 20 64 D1   516        JSR   HLIN
D32D AE 23 03   517        LDX   BXSAV
D330 60         518        RTS
D331 20 90 D3   519 BGND   JSR   PCOLR BACKGROUND CALL
D334 4C 10 D0   520        JMP   BKGNDO
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                    522 *  DRAW ROUTINES
D337 20 F9 D2       523 BDRAW1 JSR   BPOSN
D33A 20 51 D3       524 BDRAW  JSR   BDRAWX DRAW CALL FROM BASIC.
D33D 20 3B D2       525        JSR   DRAW
D340 AE 23 03       526        LDX   BXSAV
D343 60             527        RTS
D344 20 F9 D2       528 BXDRW1 JSR   BPOSN
D347 20 51 D3       529 BXDRAW JSR   BDRAWX EX-OR DRAW
D34A 20 9A D2       530        JSR   XDRAW FROM BASIC.
D34D AE 23 03       531        LDX   BXSAV
D350 60             532        RTS
D351 8E 23 03       533 BDRAWX STX   BXSAV SAVE FOR BASIC.
D354 A0 32          534        LDY   #$32
D356 20 92 D3       535        JSR   PBYTE SCALE FROM BASIC.
D359 8D 27 03       536        STA   SCALE
D35C A0 28          537        LDY   #$28
D35E 20 92 D3       538        JSR   PBYTE ROT FROM BASIC.
D361 48             539        PHA   SAVE ON STACK.
D362 AD 28 03       540        LDA   SHAPXL
D365 85 1A          541        STA   SHAPEL START OF
D367 AD 29 03       542        LDA   SHAPXH SHAPE TABLE.
D36A 85 1B          543        STA   SHAPEH
D36C A0 20          544        LDY   #$20
D36E 20 92 D3       545        JSR   PBYTE SHAPE FROM BASIC.
D371 F0 39          546        BEQ   RERR1
D373 A2 00          547        LDX   #$0
D375 C1 1A          548        CMP   (SHAPEL,X) > NUM OF SHAPES?
D377 F0 02          549        BEQ   BDRWX1
D379 B0 31          550        BCS   RERR1 YES, RANGE ERR.
D37B 0A             551 BDRWX1 ASL
D37C 90 03          552        BCC   BDRWX2
D37E E6 1B          553        INC   SHAPEH
D380 18             554        CLC
D381 A8             555 BDRWX2 TAY   SHAPE NO. * 2.
D382 B1 1A          556        LDA   (SHAPEL),Y
D384 65 1A          557        ADC   SHAPEL
D386 AA             558        TAX   ADD 2-BYTE INDEX
D387 C8             559        INY   TO SHAPE TABLE
D388 B1 1A          560        LDA   (SHAPEL),Y START ADR
D38A 6D 29 03       561        ADC   SHAPXH (X LOW, Y HI).
D38D A8             562        TAY
D38E 68             563        PLA   ROT FROM STACK.
D38F 60             564        RTS

                    566 *  BASIC PARAM FETCH SUBR'S
D390 A0 16          567 PCOLR  LDY   #$16
D392 B1 4A          568 PBYTE  LDA   (LOMEML),Y
D394 D0 16          569        BNE   RERR1 GET BASIC PARAM.
D396 88             570        DEY   (ERR IF >255)
D397 B1 4A          571        LDA   (LOMEML),Y
D399 60             572 RTSB   RTS
D39A 8E 23 03       573 GETXO  STX   BXSAV SAVE FOR BASIC.
D39D A0 05          574        LDY   #$5
D39F B1 4A          575        LDA   (LOMEML),Y XO LOW-ORDER BYTE.
D3A1 AA             576        TAX
D3A2 C8             577        INY
D3A3 B1 4A          578        LDA   (LOMEML),Y HI-ORDER BYTE.
D3A5 A8             579        TAY
D3A6 E0 18          580        CPX   #$18
D3A8 E9 01          581        SBC   #$1 RANGE ERR IF >279
D3AA 90 ED          582        BCC   RTSB
D3AC 4C 6B EE       583 RERR1  JMP   RNGERR
D3AF A0 0D          584 GETYO  LDY   #$D OFFSET TO YO FROM LOMEM
D3B1 20 92 D3       585        JSR   PBYTE GET BASIC PARAM YO.
D3B4 C9 C0          586        CMP   #$C0 (ERR IF >191)
D3B6 B0 F4          587        BCS   RERR1
D3B8 60             588        RTS
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                    590 *  SHAPE TAPE LOAD SUBROUTINE
D3B9 8E 23 03       591 SHLOAD STX   BXSAV SAVE FOR BASIC.
D3BC 20 1E F1       592        JSR   ACADR READ 2-BYTE LENGTH INTO
D3BF 20 FD FE       593        JSR   READ BASIC ACC
D3C2 A9 00          594        LDA   #$00 ;START OF SHAPE TABLE IS $0800
D3C4 85 3C          595        STA   A1L
D3C6 8D 28 03       596        STA   SHAPXL
D3C9 18             597        CLC
D3CA 65 CE          598        ADC   ACL
D3CC A8             599        TAY
D3CD A9 08          600        LDA   #$08 ;HIGH BYTE OF SHAPE TABLE POINTER.
D3CF 85 3D          601        STA   A1H
D3D1 8D 29 03       602        STA   SHAPXH
D3D4 65 CF          603        ADC   ACH
D3D6 B0 25          604        BCS   MFULL1 NOT ENOUGH MEMORY.
D3D8 C4 CA          605        CPY   PPL
D3DA 48             606        PHA
D3DB E5 CB          607        SBC   PPH
D3DD 68             608        PLA
D3DE B0 1D          609        BCS   MFULL1
D3E0 84 3E          610        STY   A2L
D3E2 85 3F          611        STA   A2H
D3E4 C8             612        INY
D3E5 D0 02          613        BNE   SHLOD1
D3E7 69 01          614        ADC   #$1
D3E9 84 4A          615 SHLOD1 STY   LOMEML
D3EB 85 4B          616        STA   LOMEMH
D3ED 84 CC          617        STY   PVL
D3EF 85 CD          618        STA   PVH
D3F1 20 FA FC       619        JSR   RD2BIT
D3F4 A9 03          620        LDA   #$3 .5 SECOND HEADER.
D3F6 20 02 FF       621        JSR   READX1
D3F9 AE 23 03       622        LDX   BXSAV
D3FC 60             623        RTS
D3FD 4C 6B E3       624 MFULL1 JMP   MEMFUL

--- END ASSEMBLY ---

TOTAL ERRORS:  00
```

```
 1 ********************************************
 2 *                                          *
 3 *  APPLE-II BASIC RENUMBER / APPEND SUBROUTINES  *
 4 *                                          *
 5 *                  VERSION  TWO            *
 6 *                    RENUMBER              *
 7 *                   >CLR                   *
 8 *                   >START=                *
 9 *                   >STEP=                 *
10 *                   >CALL -10531           *
11 *                                          *
12 *                    OPTIONAL              *
13 *                   >FROM=                 *
14 *                   >TO=                   *
15 *                   >CALL -10521           *
16 *                                          *
17 *                USE RENX ENTRY            *
18 *               FOR RENUMBER ALL           *
19 *                                          *
20 *              WOZ    APRIL 12, 1978       *
21 *               APPLE COMPUTER INC.        *
22 ********************************************

24 *
25 *
26 *         6502 EQUATES
27 *
28 ROL     EQU   $0          LOW-ORDER SW16 R0 BYTE.
29 ROH     EQU   $1           HI-ORDER.
30 ONE     EQU   $01
31 R11L    EQU   $16         LOW-ORDER SW16 R11 BYTE.
32 R11H    EQU   $17          HI-ORDER.
33 HIMEM   EQU   $4C         BASIC HIMEM POINTER.
34 PPL     EQU   $CA         BASIC PROG POINTER.
35 PVL     EQU   $CC         BASIC VAR POINTER.
36 MEMFULL EQU   $E36B        BASIC MEM FULL ERROR.
37 PRDEC   EQU   $E51B        BASIC DECIMAL PRINT SUBR.
38 RANGERR EQU   $EE68        BASIC RANGE ERROR.
39 LOAD    EQU   $FODF       BASIC LOAD SUBR.
40 SW16    EQU   $F689       SWFET 16 ENTRY.
41 CROUT   EQU   $FD8E       CAR RET SUBR.
42 COUT    EQU   $FDED       CHAR OUT SUBR.

44 *
45 *         SWEET 16 EQUATES
46 *
47 ACC     EQU   $0          SWEET 16 ACCUMULATOR.
48 NEWLOW  EQU   $1          NEW INITIAL LNO.
49 NEWINCR EQU   $2           NEW LNO INCR.
50 LNLOW   EQU   $3          LOW LNO OF RENUM RANGE.
51 LNHI    EQU   $4          HI LNO OF RENUM RANGE.
52 TBLSTRT EQU   $5           LNO TABLE START.
53 TBLNDX1 EQU   $6           PASS 1 LNO TBL INDEX.
54 TBLIM   EQU   $7          LNO TABLE LIMIT.
55 SCR8    EQU   $8          SCRATCH REG.
56 HMEM    EQU   $8          HIMEM (END OF PRGM).
57 SCR9    EQU   $9          SCRATCH REG.
58 PRGNDX  EQU   $9          PASS 1 PROG INDEX.
59 PRGNDX1 EQU   $A           ALSO PROG INDEX.
60 NEWLN   EQU   $B          NEXT "NEW LNO".
61 NEWLN1  EQU   $C          PRIOR "NEW LNO" ASSIGN.
62 TBLND   EQU   $6          PASS 2 LNO TABLE END.
63 PRGNDX2 EQU   $7           PASS 2 PROG INDEX.
64 CHR0    EQU   $9          ASCII "0".
65 CHRA    EQU   $A          ASCII "A".
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                        66 MODE    EQU   $C          CONST/LNO MODE.
                        67 TBLNDX2 EQU   $B           LNO TBL IDX FOR UPDATE.
                        68 OLDLN   EQU   $D          OLD LNO FOR UPDATE.
                        69 STRCON  EQU   $B          BASIC STR CON TOKEN.
                        70 REM     EQU   $C          BASIC REM TOKEN.
                        71 R13     EQU   $D          SWEET 16 REG 13 (CPR REG).
                        72 THEN    EQU   $D          BASIC THEN TOKEN.
                        73 LIST    EQU   $D          BASIC LIST TOKEN.
                        74 DEL     EQU   $D
                        75 SCRC    EQU   $C          SCRATCH REG FOR APPEND.

                        77 *
                        78 *          APPLE-11 BASIC RENUMBER SUBROUTINE - PASS 1
                        79          ORG   $D400
                        80          OBJ   $A400
D400 20 89 F6           81 RENX     JSR   SW16        OPTIONAL RANGE ENTRY.
D403 B0                 82          SUB   ACC
D404 33                 83          ST    LNLOW       SET LNLOW=0, LNHI=0.
D405 34                 84          ST    LNHI
D406 F4                 85          DCR   LNHI
D407 00                 86          RTN
D408 20 89 F6           87 RENUM    JSR   SW16
D408 1B 4C 00           88          SET   HMEM,HIMEM
D40E 68                 89          LDD   @HMEM
D40F 38                 90          ST    HMEM
D410 19 CE 00           91 RNUM3    SET   SCR9,PVL+2
D413 C9                 92          POPD  @SCR9       BASIC VAR PNT TO
D414 35                 93          ST    TBLSTRT      TBLSTRT AND TBLNDX1.
D415 36                 94          ST    TBLNDX1
D416 21                 95          LD    NEWLOW      COPY NEWLOW (INITIAL)
D417 3B                 96          ST    NEWLN        TO NEWLN.
D418 3C                 97          ST    NEWLN1
D419 C9                 98          POPD  @SCR9       BASIC PROG PNTR
D41A 37                 99          ST    TBLIM        TO TBLIM AND PRGNDX.
D41B 39                100          ST    PRGNDX
D41C 29                101 PASS1    LD    PRGNDX
D41D D8                102          CPR   HMEM        IF PRGNDX >= HMEM
D41E 03 46             103          BC    PASS2        THEN DONE PASS 1.
D420 3A                104          ST    PRGNDX1
D421 26                105          LD    TBLNDX1
D422 E0                106          INR   ACC         IF < TWO BYTES AVAIL IN
D423 D7                107          CPR   TBLIM        LNO TABLE THEN RETURN
D424 03 3B             108          BC    MERR         WITH "MEM FULL" MESSAGE.
D426 4A                109          LD    @PRGNDX1
D427 A9                110          ADD   PRGNDX      ADD LENTH BYTE TO PROG INDEX.
D428 39                111          ST    PRGNDX
D429 6A                112          LDD   @PRGNDX1    LINE NUMBER.
D42A D3                113          CPR   LNLOW       IF < LNLOW THEN GOTO P1B.
D42B 02 2A             114          BNC   P1B
D42D D4                115          CPR   LNHI        IF > LNHI THEN GOTO P1C.
D42E 02 02             116          BNC   P1A
D430 07 30             117          BNZ   P1C
D432 76                118 P1A      STD   @TBLNDX1    ADD TO LNO TABLE.
D433 00                119          RTN
D434 A5 01             120          LDA   ROH         **** 6502 CODE ****
D436 A6 00             121          LDX   ROL
D438 20 1B E5          122          JSR   PRDEC       PRINT OLD LNO "->" NEW LNO
D43B A9 AD             123          LDA   #$AD         (R0,R11) IN DECIMAL.
D43D 20 ED FD          124          JSR   COUT
D440 A9 BE             125          LDA   #$BE
D442 20 ED FD          126          JSR   COUT
D445 A5 17             127          LDA   R11H
D447 A6 16             128          LDX   R11L
D449 20 1B E5          129          JSR   PRDEC
D44C 20 8E FD          130          JSR   CROUT
                       131 *
D44F 20 8C F6          132          JSR   SW16+3      **** END 6502 CODE ****
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                    133 *
D452 2B             134         LD    NEWLN
D453 3C             135         ST    NEWLN1        COPY NEWLN TO NEWLN1 AND INCR
D454 A2             136         ADD   NEWINCR        NEWLN BY NEWINCR.
D455 3B             137         ST    NEWLN
D456 0D             138         HEX   0D            'NUL' (WILL SKIP NEXT INSTRUCTION)
D457 D1             139 P1B     CPR   NEWLOW       IF LOW LNO < NEW LOW THEN RANGE ERR.
D458 02 C2          140         BNC   PASS1
D45A 00             141 RERR    RTN   PRINT "RANGE ERR" MESSAGE AND RETURN.
D45B 4C 6B EE       142         JMP   RANGERR
D45E 00             143 MERR    RTN   PRINT "MEM FULL" MESSAGE AND RETURN.
D45F 4C 6B E3       144         JMP   MEMFULL
D462 EC             145 P1C     INR   NEWLN1        IF HI LNO <= MOST RECENT NEWLN THEN
D463 DC             146         CPR   NEWLN1         RANGE ERROR.
D464 02 F4          147         BNC   RERR

                    147 *
                    150 *          APPLE IC BASIC RENUMBER / APPEND SUBROUTINE - PASS 2
                    151 *
D466 19 B0 00       152 PASS2   SET   CHR0,$00B0     ASCII "0".
D469 1A C0 00       153         SET   CHRA,$00C0     ASCII "A".
D46C 27             154 P2A     LD    PRGNDX2
D46D D8             155         CPR   HMEM          IF PROG INDEX = HIMEM THEN DONE PASS 2.
D46E 03 63          156         BC    DONE
D470 E7             157         INR   PRGNDX2       SKIP LENTH BYTE.
D471 67             158         LDD   @PRGNDX2      LINE NUMBER.
D472 3D             159 UPDATE  ST    OLDLN         SAVE OLD LNO.
D473 25             160         LD    TBLSTRT
D474 3B             161         ST    TBLNDX2       INIT LNO TABLE INDEX.
D475 21             162         LD    NEWLOW        INIT NEWLN TO NEWLOW.
D476 1C             163         HEX   1C            (WILL SKIP NEXT INSTR)
D477 2C             164 UD2     LD    NEWLN1
D478 A2             165         ADD   NEWINCR       ADD INCR TO NEWLN1.
D479 3C             166         ST    NEWLN1
D47A 2B             167         LD    TBLNDX2       IF LNO TBL IDX = TBLND THEN DONE
D47B B6             168         SUB   TBLND          SCANNING LNO TABLE
D47C 03 07          169         BC    UD3
D47E 6B             170         LDD   @TBLNDX2      NEXT LNO FROM TABLE.
D47F BD             171         SUB   OLDLN         LOOP TO UD2 IF NOT SAME AS OLDLN.
D480 07 F5          172         BNZ   UD2
D482 C7             173         PGPD  @PRGNDX2      REPLACE OLD LNO WITH CORRESPONDING
D483 2C             174         LD    NEWLN1         NEW LINE.
D484 77             175         STD   @PRGNDX2
D485 1B 28 00       176 UD3     SET   STRCON,$0028  STR CON TOKEN.
D488 1C             177         HEX   1C            (SKIPS NEXT TWO INSTRUCTIONS)
D489 67             178 GOTCON  LDD   @PRGNDX2
D48A FC             179         DCR   MODE          IF MODE = 0 THEN UPDATE LNO REF.
D48B 08 E5          180         BM1   UPDATE
D48D 47             181 ITEM    LD    @PRGNDX2      BASIC TOKEN.
D48E D9             182         CPR   CHR0
D48F 02 09          183         BNC   CHKTOK        CHECK TOKEN FOR SPECIAL.
D491 DA             184         CPR   CHRA          IF >= "0" AND < "A" THEN SKIP CONST
D492 02 F5          185         BNC   GOTCON         OR UPDATE.
D494 F7             186 SKPASC  DCR   PRGNDX2
D495 67             187         LDD   @PRGNDX2      SKIP ALL NEG. BYTES OF STR CON, REM,
D496 05 FC          188         BM    SKPASC         OR NAME.
D498 F7             189         DCR   PRGNDX2
D499 47             190         LD    @PRGNDX2
```

```
D49A DB          191 CHKTOK CPR   STRCON       STR CON TOKEN?
D49B 06 F7       192        BZ    SKPASC        YES, SKIP SUBSEQUENT BYTES.
D49D 1C 5D 00    193        SET   REM,$005D
D4A0 DC          194        CPR   REM          REM TOKEN?
D4A1 06 F1       195        BZ    SKPASC        YES, SKIP SUBSEQUENT LINE.
D4A3 08 13       196        BM1   CONTST       GOSUB, LOOK FOR LINE NUMBER.
D4A5 FD          197        DCR   R13
D4A6 FD          198        DCR   R13          (TOKEN $5F IS GOTO)
D4A7 06 0F       199        BZ    CONTST
D4A9 1D 24 00    200        SET   THEN,$0024
D4AC DD          201        CPR   THEN
D4AD 06 09       202        BZ    CONTST       'THEN' LNO, LOOK FOR LNO.
D4AF F0          203        DCR   ACC
D4B0 06 BA       204        BZ    P2A          EOL (TOKEN 01)?
D4B2 1D 74 00    205        SET   LIST,$0074
D4B5 BD          206        SUB   LIST         SET MODEIF  LIST OR LIST COMMA.
D4B6 09 01       207        BNM1  CONTS2        (TOKENS $74, $75)
D4B8 B0          208 CONTST SUB   ACC          CLEAR MODE FOR LNO
D4B9 3C          209 CONTS2 ST    MODE          UPDATE CHECK.
D4BA 01 D1       210        BR    ITEM
                 212 *
                 213 *
                 214 *          APPLE IC BASIC APPEND SUBROUTINE
                 215 *
D4BC 20 89 F6    216 APPEND JSR   SW16
D4BF 1C 4E 00    217        SET   SCRC,HIMEM+2
D4C2 CC          218        POPD  @SCRC         SAVE HIMEM.
D4C3 38          219        ST    HMEM
D4C4 19 CA 00    220        SET   SCR9,PPL
D4C7 69          221        LOD   @SCR9
D4C8 7C          222        STD   @SCRC         SET HIMEM TO PRESERVE PROGRAM.
D4C9 00          223        RTN
D4CA 20 DF F0    224        JSR   LOAD          LOAD FROM TAPE.
D4CD 20 89 F6    225        JSR   SW16
D4D0 CC          226        POPD  @SCRC         RESTORE HIMEM TO SHOW BOTH PROGRAMS.
D4D1 38          227        LD    HMEM            (OLD AND NEW)
D4D2 7C          228        STD   @SCRC
D4D3 00          229 DONE   RTN   RETURN.
D4D4 60          230        RTS

---- END ASSEMBLY ----

TOTAL ERRORS: 00
```

```
: ASM
 1 ****************************
 2 *                          *
 3 *     6502 RELOCATION      *
 4 *        SUBROUTINE        *
 5 *                          *
 6 *   1. DEFINE BLOCKS       *
 7 *      *A4<A1.A2 ^Y        *
 8 *      (^Y IS CTRL-Y)      *
 9 *                          *
10 *   2. FIRST SEGMENT       *
11 *      *A4<A1.A2 ^Y        *
12 *         (IF CODE)        *
13 *                          *
14 *      *A4<A1.A2M          *
15 *         (IF MOVE)        *
16 *                          *
17 *   3. SUBSEQUENT SEGMENTS *
18 *      *.A2 ^Y OR *.A2M    *
19 *                          *
20 *     WOZ  11-10-77        *
21 *   APPLE COMPUTER INC.    *
22 *                          *
23 ****************************

25 *
26 *    RELOCATION SUBROUTINE EQUATES
27 *
28 R1L     EQU   $02 SWEET 16 REG 1.
29 INST    EQU   $0B 3-BYTE INST FIELD.
30 LENGTH  EQU   $2F LENGTH CODE
31 YSAV    EQU   $34 CMND BUF POINTER
32 A1L     EQU   $3C APPLE-II MON PARAM AREA.
33 A4L     EQU   $42 APPLE-II MON PARAM REG 4
34 IN      EQU   $0200
35 SW16    EQU   $F689 ;SWEET 16 ENTRY
36 INSDS2  EQU   $F88E ;DISASSEMBLER ENTRY
37 NXTA4   EQU   $FCB4 POINTER INCR SUBR
38 FRMBEG  EQU   $01 SOURCE BLOCK BEGIN
39 FRMEND  EQU   $02 SOURCE BLOCK END
40 TOBEG   EQU   $04 DEST BLOCK BEGIN
41 ADR     EQU   $06 ADR PART OF INST.
```

```
                        43 *
                        44 *    6502 RELOCATION SUBROUTINE
                        45 *
                        46          ORG   $D4DC
                        47          OBJ   $A4DC
D4DC A4 34              48 RELOC    LDY   YSAV CMND BUF POINTER
D4DE B9 00 02           49          LDA   IN,Y NEXT CMD CHAR
D4E1 C9 AA              50          CMP   #$AA '*'?
D4E3 D0 0C              51          BNE   RELOC2   NO, RELOC CODE SEG.
D4E5 E6 34              52          INC   YSAV ADVANCE POINTER.
D4E7 A2 07              53          LDX   #$07
D4E9 B5 3C              54 INIT     LDA   A1L,X MOVE BLOCK PARAMS
D4EB 95 02              55          STA   R1L,X   FROM APPLE-II MON
D4ED CA                 56          DEX   AREA TO SW16 AREA
D4EE 10 F9              57          BPL   INIT   R1=SOURCE BEG, R2=
D4F0 60                 58          RTS   SOURCE END, R4=DEST BEG.
D4F1 A0 02              59 RELOC2   LDY   #$02
D4F3 B1 3C              60 GETINS   LDA   (A1L),Y COPY 3 BYTES TO
D4F5 99 0B 00           61          STA   INST,Y   SW16 AREA
D4F8 88                 62          DEY
D4F9 10 F8              63          BPL   GETINS
D4FB 20 BE F8           64          JSR   INSDS2 CALCULATE LENGTH OF
D4FE A6 2F              65          LDX   LENGTH   INST FROM OPCODE.
D500 CA                 66          DEX   0=1 BYTE, 1=2 BYTES,
D501 D0 0C              67          BNE   XLATE 2=3 BYTES.
D503 A5 0B              68          LDA   INST
D505 29 0D              69          AND   #$0D WEED OUT NON-ZERO-PAGE
D507 F0 14              70          BEQ   STINST   2 BYTE INSTS (IMM).
D509 29 08              71          AND   #$08   IF ZERO PAGE ADR
D50B D0 10              72          BNE   STINST  THEN CLEAR HIGH BYTE
D50D 85 0D              73          STA   INST+2
D50F 20 89 F6           74 XLATE    JSR   SW16 IF ADR OF ZERO PAGE
D512 22                 75          LD    FRMEND   OR ABS IS IN SOURCE
D513 D6                 76          CPR   ADR   (FRM) BLOCK THEN
D514 02 06              77          BNC   SW16RT   SUBSTITUTE
D516 26                 78          LD    ADR   ADR-SOURCE BEG+DEST BEG
D517 B1                 79          SUB   FRMBEG
D518 02 02              80          BNC   SW16RT
D51A A4                 81          ADD   TOBEG
D51B 36                 82          ST    ADR
D51C 00                 83 SW16RT   RTN
D51D A2 00              84 STINST   LDX   #$00
D51F B5 0B              85 STINS2   LDA   INST,X
D521 91 42              86          STA   (A4L),Y COPY LENGTH BYTES
D523 E8                 87          INX   OF INST FROM SW16 AREA TO
D524 20 B4 FC           88          JSR   NXTA4
D527 C6 2F              89          DEC   LENGTH   DEST SEGMENT. UPDATE
D529 10 F4              90          BPL   STINS2   SOURCE,DEST SEGMENT
D52B 90 C4              91          BCC   RELOC2   POINTERS.  LOOP IF NOT
D52D 60                 92          RTS   BEYOND SOURCE SEG END.

--- END ASSEMBLY ---

TOTAL ERRORS: 00
```

```
                          1 ****************************
                          2 *                          *
                          3 *        TAPE VERIFY       *
                          4 *                          *
                          5 *          JAN 78          *
                          6 *          BY WOZ          *
                          7 *                          *
                          8 *                          *
                          9 ****************************

                         11 *
                         12 *     TAPE VERIFY EQUATES
                         13 *
                         14 CHKSUM EQU   $2E
                         15 A1     EQU   $3C
                         16 HIMEM  EQU   $4C ;BASIC HIMEM POINTER
                         17 PP     EQU   $CA ;BASIC BEGIN OF PROGRAM
                         18 PRLEN  EQU   $CE ;BASIC PROGRAM LENGTH
                         19 XSAVE  EQU   $D8 ;PRESERVE X-REG FOR BASIC
                         20 HDRSET EQU   $F11E ;SETS TAPE POINTERS TO $CE.CF
                         21 PRGSET EQU   $F12C ;SETS TAPE POINTERS FOR PROGRAM
                         22 NXTA1  EQU   $FCBA ;INCREMENTS (A1) AND COMPARES TO (A2)
                         23 HEADR  EQU   $FCC9
                         24 RDBYTE EQU   $FCEC
                         25 RD2BIT EQU   $FCFA
                         26 RDBIT  EQU   $FCFD
                         27 PRA1   EQU   $FD92 ;PRINT (A1)-
                         28 PRBYTE EQU   $FDDA
                         29 COUT   EQU   $FDED
                         30 FINISH EQU   $FF26 ;CHECK CHECKSUM, RING BELL
                         31 PRERR  EQU   $FF2D

                         33 *
                         34 *       TAPE VERIFY ROUTINE
                         35 *
                         36        ORG   $D535
                         37        OBJ   $A535
D535 86 D8               38 VFYBSC STX   XSAVE ;PRESERVE X-REG FOR BASIC
D537 38                  39        SEC
D538 A2 FF               40        LDX   #$FF
D53A A5 4D               41 GETLEN LDA   HIMEM+1 ;CALCULATE PROGRAM LENGTH
D53C F5 CB               42        SBC   PP+1,X ;INTO PRLEN
D53E 95 CF               43        STA   PRLEN+1,X
D540 E8                  44        INX
D541 F0 F7               45        BEQ   GETLEN
D543 20 1E F1            46        JSR   HDRSET ;SET UP POINTERS
D546 20 54 D5            47        JSR   TAPEVFY ;DO A VERIFY ON HEADER
D549 A2 01               48        LDX   #$01 ;PREPARE FOR PRGSET
D54B 20 2C F1            49        JSR   PRGSET ;SET POINTERS FOR PROGRAM VERIFY
D54E 20 54 D5            50        JSR   TAPEVFY
D551 A6 D8               51        LDX   XSAVE ;RESTORE X-REG
D553 60                  52        RTS
```

```
                    53 *
                    54 * TAPE VERIFY RAM IMAGE (A1.A2)
                    55 *
D554 20 FA FC       56 TAPEVFY JSR   RD2BIT
D557 A9 16          57         LDA   #$16
D559 20 C9 FC       58         JSR   HEADR ;SYNCHRONIZE ON HEADER
D55C 85 2E          59         STA   CHKSUM ;INITIALIZE CHKSUM
D55E 20 FA FC       60         JSR   RD2BIT
D561 A0 24          61 VRFY2   LDY   #$24
D563 20 FD FC       62         JSR   RDBIT
D566 B0 F9          63         BCS   VRFY2 ;CARRY SET IF READ A '1' BIT
D568 20 FD FC       64         JSR   RDBIT
D56B A0 3B          65         LDY   #$3B
D56D 20 EC FC       66 VRFY3   JSR   RDBYTE ;READ A BYTE
D570 F0 0E          67         BEQ   EXTDEL ;ALWAYS TAKEN
D572 45 2E          68 VFYLOOP EOR   CHKSUM ;UPDATE CHECKSUM
D574 85 2E          69         STA   CHKSUM
D576 20 BA FC       70         JSR   NXTA1 ;INCREMENT A1, SET CARRY IF A1>A2
D579 A0 34          71         LDY   #$34 ;ONE LESS THAN USED IN READ FOR EXTRA 12
D57B 90 F0          72         BCC   VRFY3 ;LOOP UNTIL A1>A2
D57D 4C 26 FF       73         JMP   FINISH ;VERIFY CHECKSUM&RING BELL
D580 EA             74 EXTDEL  NOP   ;EXTRA DELAY TO EQUALIZE TIMING
D581 EA             75         NOP   ;     (+12 USEC)
D582 EA             76         NOP
D583 C1 3C          77         CMP   (A1,X) ;BYTE THE SAME?
D585 F0 EB          78         BEQ   VFYLOOP ;IT MATCHES, LOOP BACK
D587 48             79         PHA   ;SAVE WRONG BYTE FROM TAPE
D588 20 2D FF       80         JSR   PRERR ;PRINT "ERR"
D58B 20 92 FD       81         JSR   PRA1 ;OUTPUT (A1)"-"
D58E B1 3C          82         LDA   (A1),Y
D590 20 DA FD       83         JSR   PRBYTE ;OUTPUT CONTENTS OF A1
D593 A9 A0          84         LDA   #$A0 ;PRINT A BLANK
D595 20 ED FD       85         JSR   COUT
D598 A9 A8          86         LDA   #$A8 ;  '('
D59A 20 ED FD       87         JSR   COUT
D59D 68             88         PLA   ;OUTPUT BAD BYTE FROM TAPE
D59E 20 DA FD       89         JSR   PRBYTE
D5A1 A9 A9          90         LDA   #$A9 ;  ')'
D5A3 20 ED FD       91         JSR   COUT
D5A6 A9 8D          92         LDA   #$8D ;CARRIAGE RETURN, AND RETURN TO CALLER
D5A8 4C ED FD       93         JMP   COUT

--- END ASSEMBLY ---

TOTAL ERRORS: 00
```

```
: ASM
 1 ***************************
 2 *                         *
 3 *        RAMTEST:         *
 4 *                         *
 5 *         BY WOZ          *
 6 *          6/77           *
 7 *                         *
 8 *   COPYRIGHT 1978 BY:    *
 9 *   APPLE COMPUTER INC    *
10 *                         *
11 ***************************

13 *
14 *       EQUATES:
15 *
16 DATA    EQU   $0 TEST DATA $00 OR $FF
17 NDATA   EQU   $1 INVERSE TEST DATA.
18 TESTD   EQU   $2 GALLOP DATA.
19 R3L     EQU   $6 AUX ADR POINTER.
20 R3H     EQU   $7
21 R4L     EQU   $8 AUX ADR POINTER.
22 R4H     EQU   $9
23 R5L     EQU   $A AUX ADR POINTER.
24 R5H     EQU   $B
25 R6L     EQU   $C GALLOP BIT MASK.
26 R6H     EQU   $D ($0001 TO 2^N)
27 YSAV    EQU   $34 MONITOR SCAN INDEX.
28 A1H     EQU   $3D BEGIN TEST BLOCK ADR.
29 A2L     EQU   $3E LEN (PAGES) FROM MON.
30 SETCTLY EQU    $D5B0 ;SET UP CNTRL-Y LOCATION
31 PRBYTE EQU   $FDDA BYTE PRINT SUBR.
32 COUT    EQU   $FDED CHAR OUT SUBR.
33 PRERR   EQU   $FF2D PRINTS 'ERR-BELL'
34 BELL    EQU   $FF3A
```

```
                        36 *
                        37 *      RAMTEST:
                        38 *
                        39          ORG   $D5BC
                        40          OBJ   $A5BC
D5BC A9 C3              41 SETUP    LDA   #$C3 ;SET UP CNTRL-Y LOCATION
D5BE A0 D5              42          LDY   #$D5
D5C0 4C B0 D5           43          JMP   SETCTLY
D5C3 A9 00              44 RAMTST   LDA   #$0 TEST FOR $00,
D5C5 20 D0 D5           45          JSR   TEST
D5C8 A9 FF              46          LDA   #$FF THEN $FF.
D5CA 20 D0 D5           47          JSR   TEST
D5CD 4C 3A FF           48          JMP   BELL
D5D0 85 00              49 TEST     STA   DATA
D5D2 49 FF              50          EOR   #$FF
D5D4 85 01              51          STA   NDATA
D5D6 A5 3D              52          LDA   A1H
D5D8 85 07              53          STA   R3H INIT (R3L,R3H),
D5DA 85 09              54          STA   R4H   (R4L,R4H), (R5L,R5H)
D5DC 85 0B              55          STA   R5H   TO TEST BLOCK BEGIN
D5DE A0 00              56          LDY   #$0   ADDRESS.
D5E0 84 06              57          STY   R3L
D5E2 84 08              58          STY   R4L
D5E4 84 0A              59          STY   R5L
D5E6 A6 3E              60          LDX   A2L LENGTH (PAGES).
D5E8 A5 00              61          LDA   DATA
D5EA 91 08              62 TEST01   STA   (R4L),Y SET ENTIRE TEST
D5EC C8                 63          INY   BLOCK TO DATA.
D5ED D0 FB              64          BNE   TEST01
D5EF E6 09              65          INC   R4H
D5F1 CA                 66          DEX
D5F2 D0 F6              67          BNE   TEST01
D5F4 A6 3E              68          LDX   A2L
D5F6 B1 06              69 TEST02   LDA   (R3L),Y VERIFY ENTIRE
D5F8 C5 00              70          CMP   DATA   TEST BLOCK.
D5FA F0 13              71          BEQ   TEST03
D5FC 48                 72          PHA   PRESERVE BAD DATA.
D5FD A5 07              73          LDA   R3H
D5FF 20 DA FD           74          JSR   PRBYTE PRINT ADDRESS,
D602 98                 75          TYA
D603 20 8A D6           76          JSR   PRBYSP
D606 A5 00              77          LDA   DATA THEN EXPECTED DATA,
D608 20 8A D6           78          JSR   PRBYSP
D60B 68                 79          PLA   THEN BAD DATA,
D60C 20 7F D6           80          JSR   PRBYCR   THEN 'ERR-BELL'.
D60F C8                 81 TEST03   INY
D610 D0 E4              82          BNE   TEST02
D612 E6 07              83          INC   R3H
D614 CA                 84          DEX
D615 D0 DF              85          BNE   TEST02
D617 A6 3E              86          LDX   A2L LENGTH.
D619 A5 01              87 TEST04   LDA   NDATA
D61B 91 0A              88          STA   (R5L),Y SET TEST CELL TO
D61D 84 0D              89          STY   R6H   NDATA AND R6
D61F 84 0C              90          STY   R6L   (GALLOP BIT MASK)
D621 E6 0C              91          INC   R6L   TO $0001.
D623 A5 01              92 TEST05   LDA   NDATA
D625 20 45 D6           93          JSR   TEST6 GALLOP WITH NDATA.
D628 A5 00              94          LDA   DATA
D62A 20 45 D6           95          JSR   TEST6 THEN WITH DATA.
D62D 06 0C              96          ASL   R6L
D62F 26 0D              97          ROL   R6H SHIFT GALLOP BIT
D631 A5 0D              98          LDA   R6H   MASK FOR NEXT
```

```
D633 C5 3E        99          CMP   A2L   NEIGHBOR.   DONE
D635 90 EC       100          BCC   TEST05   IF > LENGTH.
D637 A5 00       101          LDA   DATA
D639 91 0A       102          STA   (R5L),Y RESTORE TEST CELL.
D63B E6 0A       103          INC   R5L
D63D D0 DA       104          BNE   TEST04
D63F E6 0B       105          INC   R5H INCR TEST CELL
D641 CA          106          DEX   POINTER AND DECR
D642 D0 D5       107          BNE   TEST04   LENGTH COUNT.
D644 60          108 RTS1     RTS
D645 85 02       109 TEST6    STA   TESTD SAVE GALLOP DATA.
D647 A5 0A       110          LDA   R5L
D649 45 0C       111          EOR   R6L SET R4 TO R5
D64B 85 08       112          STA   R4L   EX-OR R6
D64D A5 0B       113          LDA   R5H   FOR NEIGHBOR
D64F 45 0D       114          EOR   R6H   ADDRESS (1 BIT
D651 85 09       115          STA   R4H   DIFFERENCE).
D653 A5 02       116          LDA   TESTD
D655 91 08       117          STA   (R4L),Y GALLOP TEST DATA.
D657 B1 0A       118          LDA   (R5L),Y CHECK TEST CELL
D659 C5 01       119          CMP   NDATA   FOR CHANGE.
D65B F0 E7       120          BEQ   RTS1 (OK).
D65D 48          121          PHA   PRESERVE FAIL DATA.
D65E A5 0B       122          LDA   R5H
D660 20 DA FD    123          JSR   PRBYTE PRINT TEST CELL
D663 A5 0A       124          LDA   R5L   ADDRESS,
D665 20 8A D6    125          JSR   PRBYSP
D668 A5 01       126          LDA   NDATA
D66A 91 0A       127          STA   (R5L),Y (REPLACE CORRECT DATA)
D66C 20 8A D6    128          JSR   PRBYSP   THEN TEST DATA BYTE,
D66F 68          129          PLA
D670 20 8A D6    130          JSR   PRBYSP   THEN FAIL DATA,
D673 A5 09       131          LDA   R4H
D675 20 DA FD    132          JSR   PRBYTE
D678 A5 08       133          LDA   R4L   THEN NEIGHBOR ADR,
D67A 20 8A D6    134          JSR   PRBYSP
D67D A5 02       135          LDA   TESTD   THEN GALLOP DATA.
D67F 20 8A D6    136 PRBYCR   JSR   PRBYSP OUTPUT BYTE, SPACE.
D682 20 2D FF    137          JSR   PRERR   THEN 'ERR-BELL'.
D685 A9 8D       138          LDA   #$8D ASCII CAR. RETURN.
D687 4C ED FD    139          JMP   COUT
D68A 20 DA FD    140 PRBYSP   JSR   PRBYTE
D68D A9 A0       141          LDA   #$A0 OUTPUT BYTE, THEN
D68F 4C ED FD    142          JMP   COUT   SPACE.
                 143          ORG   $3F8
03F8 4C C3 D5    144 USRLOC   JMP   RAMTST ENTRY FROM MON (CTRL-Y)

--- END ASSEMBLY ---

TOTAL ERRORS: 00
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```
                    ********************************
                    *
                    * MUSIC SUBROUTINE
                    *
                    * GARY J. SHANNON
                    *
                    ********************************
                          ORG   $D717
                    *
                    * ZERO PAGE WORK AREAS
                    * PARAMETER PASSING AREAS
                    *
DOWNTIME EQU   $0
UPTIME EQU   $1
LENGTH EQU   $2
VOICE  EQU   $2FD
LONG   EQU   $2FE
NOTE   EQU   $2FF
SPEAKER EQU   $C030
D717 4C 4E D7       ENTRY  JMP   LOOKUP
                    *
                    * PLAY ONE NOTE
                    *
                    * DUTY CYCLE DATA IN 'UPTIME' AND
                    * 'DOWNTIME', DURATION IN 'LENGTH'
                    *
                    *
                    * CYCLE IS DIVIDED INTO 'UP' HALF
                    * AND 'DOWN' HALF
                    *
D71A A4 01          PLAY   LDY   UPTIME ; GET POSITIVE PULSE WIDTH
D71C AD 30 C0       PLAY2  LDA   SPEAKER ; TOGGLE SPEAKER
D71F E6 02          PLAY2  INC   LENGTH ; DURATION
D721 D0 05          PATH1 ; NOT EXPIRED
D723 E6 03          PATH1  INC   LENGTH+1
D725 D0 05          PATH2
D727 60             PATH2  RTS   ; DURATION EXPIRED
D728 EA             PATH1  NOP   , DUMMY
D729 4C 2C D7       PATH2  JMP   PATH2 ; TIME ADJUSTMENTS
D72C 88             PATH2  DEY   ; DECREMENT WIDTH
D72D F0 05          DOWN ; WIDTH EXPIRED
D72F 4C 32 D7       PATH3 ; IF NOT, USE UP
                    *
                    * DOWN HALF OF CYCLE
                    *
D732 D0 EB          PATH3  BNE   PLAY2 ; SAME # CYCLES
D734 A4 00          DOWN   LDY   DOWNTIME ; GET NEGATIVE PULSE WIDTH
D736 AD 30 C0       PLAY3  LDA   SPEAKER ; TOGGLE SPEAKER
D739 E6 02          PLAY3  INC   LENGTH ; DURATION
D73B D0 05          PATH4 ; NOT EXPIRED
D73D E6 03          PATH4  INC   LENGTH+1
D73F D0 05          PATH5
D741 60             PATH5  RTS   ; DURATION EXPIRED
D742 EA             PATH4  NOP   ; DUMMY
D743 4C 46 D7       PATH5 ; TIME ADJUSTMENTS
D746 88             PATH5  DEY   ; DECREMENT WIDTH
D747 F0 D1          PLAY ; BACK TO UP-SIDE
D749 4C 4C D7       PATH6 ; USE UP SOME CYCLES
D74C D0 EB          PATH6  BNE   PLAY3 ; REPEAT
```

```
                    62 *
                    63 * NOTE TABLE LOOKUP SUBROUTINE
                    64 *
                    65 * GIVEN NOTE NUMBER IN 'NOTE'
                    66 * DURATION COUNT IN 'LONG'
                    67 * FIND 'UPTIME' AND 'DOWNTIME'
                    68 * ACCORDING TO DUTY CYCLE CALLED
                    69 * FOR BY 'VOICE'.
                    70 *
D74E AD FF 02        71 LOOKUP LDA   NOTE ; GET NOTE NUMBER
D751 0A              72        ASL   ; DOUBLE IT
D752 A8              73        TAY
D753 B9 96 D7        74        LDA   NOTES,Y ; GET UPTIME
D756 85 00           75        STA   DOWNTIME ; SAVE IT
D758 AD FD 02        76        LDA   VOICE ; GET DUTY CYCLE
D75B 4A              77 SHIFT  LSR
D75C F0 04           78        BEQ   DONE ; SHIFT WIDTH COUNT
D75E 46 00           79        LSR   DOWNTIME ; ACCORDING TO VOICE
D760 D0 F9           80        BNE   SHIFT
D762 B9 96 D7        81 DONE   LDA   NOTES,Y ; GET ORIGINAL
D765 38              82        SEC
D766 E5 00           83        SBC   DOWNTIME ; COMPUTE DIFFERENCE
D768 85 01           84        STA   UPTIME ; SAVE IT
D76A C8              85        INY   ; NEXT ENTRY
D76B B9 96 D7        86        LDA   NOTES,Y ; GET DOWNTIME
D76E 65 00           87        ADC   DOWNTIME ; ADD DIFFERENCE
D770 85 00           88        STA   DOWNTIME
D772 A9 00           89        LDA   #0
D774 38              90        SEC
D775 ED FE 02        91        SBC   LONG ; GET COMPLIMENT OF DURATION
D778 85 03           92        STA   LENGTH+1 MOST SIGNIFICANT BYTE
D77A A9 00           93        LDA   #0
D77C 85 02           94        STA   LENGTH
D77E A5 01           95        LDA   UPTIME
D780 D0 98           96        BNE   PLAY ; IF NOT NOTE #0, PLAY IT
                     97 *
                     98 * 'REST' SUBROUTINE' PLAYS NOTE #0
                     99 * SILENTLY, FOR SAME DURATION AS
                    100 * A REGULAR NOTE.
                    101 *
D782 EA             102 REST   NOP   ; DUMMY
D783 EA             103        NOP   ; CYCLE USERS
D784 4C 87 D7       104        JMP   REST2 ; TO ADJUST TIME
D787 E6 02          105 REST2  INC   LENGTH
D789 D0 05          106        BNE   REST3
D78B E6 03          107        INC   LENGTH+1
D78D D0 05          108        BNE   REST4
D78F 60             109        RTS   ; IF DURATION EXPIRED
D790 EA             110 REST3  NOP   ; USE UP 'INC' CYCLES
D791 4C 94 D7       111        JMP   REST4
D794 D0 EC          112 REST4  BNE   REST ; ALWAYS TAKEN
```

```
                    113 *
                    114 * NOTE TABLES
                    115 *
D796 00 00 F6       116 NOTES   HEX     00,00,F6,F6,E8,E8,DB,DB
D79E CF CF C3       117         HEX     CF,CF,C3,C3,B8,B8,AE,AE
D7A6 A4 A4 9B       118         HEX     A4,A4,9B,9B,92,92,8A,8A
D7AE 82 82 7B       119         HEX     82,82,7B,7B,74,74,6D,6E
D7B6 67 68 61       120         HEX     67,68,61,62,5C,5C,57,57
D7BE 52 52 4D       121         HEX     52,52,4D,4E,49,49,45,45
D7C6 41 41 3D       122         HEX     41,41,3D,3E,3A,3A,36,37
D7CE 33 34 30       123         HEX     33,34,30,31,2E,2E,2B,2C
D7D6 29 29 26       124         HEX     29,29,26,27,24,25,22,23
D7DE 20 21 1E       125         HEX     20,21,1E,1F,1D,1D,1B,1C
D7E6 1A 1A 18       126         HEX     1A,1A,18,19,17,17,15,16
D7EE 14 15 13       127         HEX     14,15,13,14,12,12,11,11
D7F6 10 10 0F       128         HEX     10,10,0F,10,0E,0F

--- END ASSEMBLY ---

TOTAL ERRORS: 00
```

APPENDIX II
SUMMARY OF PROGRAMMER'S AID COMMANDS

Chapter 1: RENUMBER

(a) To renumber an entire BASIC program:

```
CLR
START = 1ØØØ
STEP = 1Ø
CALL -1Ø531
```

(b) To renumber a program portion:

```
CLR
START = 2ØØ
STEP = 2Ø

FROM = 3ØØ                (program portion
TO = 5ØØ                  to be renumbered)

CALL -1Ø521
```

Chapter 2: APPEND

(a) Load the second BASIC program, with high line numbers:

```
LOAD
```

(b) Load and append the first BASIC program, with low line numbers:

```
CALL -11Ø76
```

Chapter 3: TAPE VERIFY (BASIC)

(a) Save current BASIC program on tape:

```
SAVE
```

(b) Replay the tape, after:

```
CALL -1Ø955
```

Chapter 4: TAPE VERIFY (Machine Code and Data)

(a) From the Monitor, save the portion of memory on tape:

address1 . address2 W return

(b) Initialize Tape Verify feature:

D52EG return

(c) Replay the tape, after:

address1 . address2 ctrl Y return

Note: spaces shown within the above commands are for easier reading only; they should not be typed.

Chapter 5: RELOCATE (Machine Code and Data)

(a) From the Monitor, initialize Code-Relocation feature:

D4D5G return

(b) Blocks are memory locations from which program runs. Specify Destination and Source Block parameters:

Dest Blk Beg < Source Blk Beg . Source Blk End ctrl Y * return

(c) Segments are memory locations where parts of program reside. If first program Segment is code, Relocate:

Dest Seg Beg < Source Seg Beg . Source Seg End ctrl Y return

If first program Segment is data, Move:

Dest Seg Beg < Source Seg Beg . Source Seg End return

(d) In order of increasing address, Move subsequent contiguous data Segments:

. Source Segment End ctrl Y return

and Relocate subsequent contiguous code Segments:

. Source Segment End M return

Note: spaces shown within the above commands are for easier reading only; they should not be typed.

Chapter 6: RAM TEST

(a) From the Monitor, initialize RAM Test program:

```
D5BCG return
```

(b) To test a portion of memory:

```
address . pages  ctrl Y  return        (test begins at address,
                                        continues for length pages.
```

Note: test length, pages*1ØØ, must not be greater than starting address. One page = 256 bytes ($1ØØ bytes, in Hex).

(c) To test more memory, do individual tests or concatenate:

```
addr1.pages1 ctrl Y addr2.pages2 ctrl Y addr3.pages3 ctrl Y return
```

Example, for a 48K system:

```
4ØØ.4 ctrl Y 8ØØ.8 ctrl Y 1ØØØ.1Ø ctrl Y 2ØØØ.2Ø ctrl Y
3ØØØ.2Ø ctrl Y 4ØØØ.4Ø ctrl Y 7ØØØ.2Ø ctrl Y 8ØØØ.4Ø
ctrl Y return
```

(d) To repeat test indefinitely:

```
N  complete test  34:Ø   type one space   return
```

Note: except where specified in step (d), spaces shown within the above commands are for easier reading only; they should not be typed.

Chapter 7: MUSIC

(a) Assign appropriate variable names to CALL and POKE locations (optional):

```
MUSIC = -1Ø473
PITCH = 767
TIME = 766
TIMBRE = 765
```

(b) Set parameters for next note:

```
POKE PITCH, p                  (p = 1 to 5Ø; 32 = middle C)
POKE TIME, m                   (m = 1 to 255; 17Ø = 1 second)
POKE TIMBRE, t                 (t = 2, 8, 16, 32 or 64)
```

(c) Sound the note:

```
CALL MUSIC
```

(a) Set order of parameters (first lines of program):

```
1  XØ = YØ = COLR
2  SHAPE = ROT = SCALE              (if shapes are used)
```

(b) Assign appropriate variable names to subroutine calling addresses (optional; omit any subroutines not used in program):

```
1Ø  INIT = -12288 : CLEAR = -12274 : BKGND = -11471
11  POSN = -11527 : PLOT = -115Ø6 : LINE = -115ØØ
12  DRAW = -11465 : DRAW1 = -11462
13  FIND = -1178Ø : SHLOAD = -11335
```

(c) Assign appropriate variable names to color values (optional; omit any colors not used in program):

```
2Ø  BLACK = Ø : LET GREEN = 42 : VIOLET = 85
21  WHITE = 127 : ORANGE = 17Ø : BLUE = 213
22  BLACK2 = 128 : WHITE2 = 255
```

(d) Initialize:

```
3Ø  CALL INIT
```

(e) Change screen conditions, if desired. Set appropriate parameter values, and CALL desired subroutines by name.

Example:

```
4Ø  COLR = VIOLET : CALL BKGND : REM  TURN BACKGROUND VIOLET
5Ø  FOR I = Ø TO 279 STEP 5
6Ø  XØ = 14Ø : YØ = 15Ø : COLR = WHITE : REM  SET PARAMETERS
7Ø  CALL POSN : REM  MARK THE "CENTER"
8Ø  XØ = I : YØ = Ø : REM  SET NEW PARAMETERS
9Ø  CALL LINE : REM  DRAW LINE TO EDGE
1ØØ  NEXT I : END
```

QUICK REFERENCE TO HIGH-RESOLUTION INFORMATION

Subroutine Name	CALLing Address	Parameters Needed
INIT	-12288	
CLEAR	-12274	
BKGND	-11471	COLR
POSN	-11527	XØ, YØ, COLR
PLOT	-115Ø6	XØ, YØ, COLR
LINE	-115ØØ	XØ, YØ, COLR
DRAW	-11465	XØ, YØ, COLR, SHAPE, ROT, SCALE
DRAW1	-11462	SHAPE, ROT, SCALE
FIND	-1178Ø	
SHLOAD	-11335	

Color Name	COLR Value	Color Name	COLR Value
BLACK	Ø	BLACK2	128
GREEN	42	ORANGE	17Ø
VIOLET	85	BLUE	213
WHITE	127	WHITE2	255

(Note: on systems below S/N 6ØØØ, colors in the second column appear identical to those in the first column)

CHANGING THE HIGH-RESOLUTION GRAPHICS DISPLAY

Full-Screen Graphics	POKE -163Ø2, Ø
Mixed Graphics-Plus-Text (Default)	POKE -163Ø1, Ø
Page 2 Display	POKE -16299, Ø
Page 1 Display (Normal)	POKE -163ØØ, Ø
Page 2 Plotting	POKE 8Ø6, 64
Page 1 Plotting (Default)	POKE 8Ø6, 32

(Note: CALL INIT sets mixed graphics-plus-text, and Page 1 plotting, but does not reset to Page 1 display.)

Collision Count for Shapes PEEK (81Ø)

(Note: the change in PEEKed value indicates collision.)